SBIR

Small Business Innovation Research for FY 1998

DOC PROGRAM SOLICITATION

Closing Date: January 14, 1998

October 1997

DOC 98-1

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U.S. DEPARTMENT OF COMMERCE

PROGRAM SOLICITATION FOR SMALL BUSINESS INNOVATION RESEARCH

1.0 PROGRAM DESCRIPTION

1.1 Introduction

The Department of Commerce (DOC) invites small businesses to submit research proposals under this solicitation entitled "Small Business Innovation Research (SBIR)." Firms with strong research capabilities in any of the areas listed in Section 8 of this solicitation are encouraged to participate. **Unsolicited proposals are not accepted under the SBIR program**.

Objectives of this solicitation include stimulating technological innovation in the private sector, strengthening the role of small business in meeting Federal research and development (R&D) needs, increasing the commercial application of innovations derived from Federal research, and improving the return on investment from Federally-funded research for the economic benefit of the Nation.

1.2 Three-Phase Program

The "Small Business Research and Development Enhancement Act of 1992" (P.L. 102-564) was signed by the President on October 28, 1992, and is operated under a Small Business Administration (SBA) directive dated January 26, 1993. The Act requires the Department of Commerce to establish a three-phase SBIR program by reserving a percentage of its extramural R&D budget to be awarded to small business concerns for innovation research.

The funding vehicles for DOC's SBIR program in both Phase 1 and Phase 2 are primarily contracts, although at DOC's discretion, some research topics may be funded by grants.

DOC has the unilateral right to select SBIR research topics and awardees in both Phase 1 and Phase 2, and to award several or no contracts or grants under a given topic.

1.2.1 Phase 1 - Feasibility Research

Phase 1 is to determine the technical feasibility of ideas submitted for consideration and the quality of performance of the small business concern receiving an award.

Therefore, the proposal should concentrate on research that will significantly contribute to proving the feasibility of the approach, a prerequisite to further support in Phase 2.

1.2.2 Phase 2 - Research and Development

Only firms that are awarded Phase 1 contracts or grants under this solicitation will be given the opportunity of submitting a Phase 2 proposal immediately following completion of Phase 1.

Phase 2 is the R&D or prototype development phase. It will require a comprehensive proposal outlining the effort in detail. Further information regarding Phase 2 proposal requirements will be provided to all firms receiving Phase 1 contracts or grants.

1.2.3 Phase 3 - Commercialization

In Phase 3, it is intended that non-SBIR capital be used by the small business to pursue commercial applications of Phase 2.

1.3 Eligibility

Each organization submitting a proposal **must** qualify as a small business (Section 2.1) for research or R&D purposes (Section 2.2).

In addition, the primary employment of the principal investigator must be with the small business at the time of the award. More than one-half of the principal investigator's time must be spent with the small business for the period covered by the award. **Primary employment with a small business precludes full-time employment with another organization.**

Also, for both Phase 1 and Phase 2, the work must be performed in the United States. "United States" means the fifty states, the territories and possessions of the United States, the Commonwealth of Puerto Rico, the Commonwealth of the Northern Mariana Islands, the Trust Territory of the Pacific Islands, and the District of Columbia.

Joint ventures and limited partnerships are eligible, provided the entity created qualifies as a small business as defined in this solicitation. **Consultative arrangements between firms and universities or other non-profit organizations are encouraged, with the small business serving as the prime contractor.**

1.4 Contact with DOC

In the interest of competitive fairness, oral or written communication with DOC or any of its components concerning additional information on the technical topics described in Section 8 of this solicitation **is prohibited**.

Requests for general information on the DOC SBIR program may be addressed to:

Dr. Joseph M. Bishop or
DOC SBIR Program Manager
1315 East-West Highway
Silver Spring, MD 20910
Telephone: (301) 713-3565
Fax: (301) 713-4100
E-mail: joseph.bishop@noaa.gov

Mr. Norman Taylor
NIST SBIR Program Manager
Building 820, Room 306
Gaithersburg, MD 20899
Telephone: (301) 975-4517
Fax: (301) 548-0624
E-mail: norman.taylor@nist.gov

Information sources and/or document services are listed in Section 7.

2.0 DEFINITIONS

2.1 Small Business

A small business concern is one that, at the time of award for Phase 1 and Phase 2:

(a) is independently owned and operated, is organized for profit, is not dominant in the field of operation in which it is proposing, and has its principal place of business located in the United States (Section 1.3);

(b) is at least 51 percent owned, or in the case of a publicly owned business, at least 51 percent of its voting stock is owned by United States citizens or lawfully admitted permanent resident aliens; and

(c) has, including its affiliates, a number of employees not exceeding 500, and meets the other small business regulatory requirements found in 13 Code of Federal Regulations Part 121. Business concerns are affiliates of one another when, either directly or indirectly, (1) one concern controls or has the power to control the other, or (2) a third party controls both. Control can be exercised through common ownership, common management, and contractual relationships. Business concerns include, but are not limited to, any individual, partnership, joint venture, association, or cooperative.

2.2 Research or Research and Development

Any activity that is (a) a systematic, intensive study directed toward greater knowledge or understanding of the subject studied; (b) a systematic study directed specifically toward applying new knowledge to meet a recognized need; or (c) a systematic application of knowledge toward the production of useful materials, devices, services, or methods, and includes design, development, and improvement of prototypes and new processes to meet specific requirements.

In general, the DOC SBIR program will fund Phase 1 and 2 proposals with objectives that can be defined by (b) and (c) above.

2.3 Socially and Economically Disadvantaged Small Business Concern

Is one that is:

(a) at least 51 percent owned by (1) an American Indian tribe or a native Hawaiian organization, or (2) one or more socially and economically disadvantaged individuals, and

(b) controlled by one or more such individuals in its management and daily business operations.

A socially and economically disadvantaged individual is defined as a member of any of the following groups: Black Americans, Hispanic Americans, Native Americans, Asian-Pacific Americans, Subcontinent Asian Americans, or any other individual found to be socially and economically disadvantaged by the Small Business Administration (SBA) pursuant to Section 8(a) of the Small Business Act, 15 U.S. Code (U.S.C.) 637(a).

2.4 Women-Owned Small Business

A small business that is at least 51 percent owned by a woman or women who also control and operate it. "Control" in this context means exercising the power to make policy decisions. "Operate" in this context means being actively involved in the day-to-day management.

2.5 Subcontract

Any agreement, other than one involving an employer-employee relationship, entered into by a Federal Government funding awardee, calling for supplies or services required solely for the performance of the original funding agreement.

2.6 Commercialization

This is the process of locating or developing markets and producing and delivering products for sale (whether by the originating party or by others). As used here, commercialization includes both Government and private sector markets.

3.0 PROPOSAL PREPARATION

3.1 Proposal Requirements

The objective is to provide sufficient information to demonstrate that the proposed work represents a sound approach to the investigation of an important scientific or engineering innovation worthy of support. **It must meet all the requirements of the subtopic in Section 8 to which it applies**.

A proposal must be self-contained and written with all the care and thoroughness of a scientific paper submitted for publication. It should indicate a thorough knowledge of the current status of research in the subtopic addressed by the proposal. Each proposal should be checked carefully by the offeror to ensure inclusion of all essential material needed for a complete evaluation. It must contain adequate information to be peer reviewed as research. All units of measurement should be in the metric system.

DOC reserves the right not to submit to technical review any proposal which it finds to have insufficient scientific and technical information or one which fails to comply with the administrative procedures as outlined on the Checklist of Requirements in Section 9.

The proposal must not only be responsive to the specific DOC program interests described in Section 8 of the solicitation, but it also should serve as the basis for technological innovation leading to new commercial products, processes, or services that benefit the public. An organization may submit different proposals on different subtopics or different proposals on the same subtopic under this solicitation. Where the proposed innovation applies to more than one subtopic, the offeror must choose that subtopic which is most relevant to the offeror's technical concept.

Proposals principally for the commercialization of proven concepts or for market research must not be submitted for Phase 1 funding, since such efforts are considered the responsibility of the private sector.

The proposal should be direct, concise, and informative. Promotional and other material not related to the project should be omitted. **The Phase 1 proposal must describe potential commercial applications.**

3.2 Phase 1 Proposal Limitations

- Page Length - no more than 25 pages, consecutively numbered, including the cover page, project summary, main text, references, resumes, any other enclosures or attachments, and the proposal summary budget.
- Paper Size - must be 21.6 cm X 27.9 cm (8 ½" X 11").
- Print Size - **must be easy to read with a fixed pitch font of 12 or fewer characters per inch or proportionally spaced font of point size 10 or larger with no more than 6 lines per inch.**

Supplementary material, revisions, substitutions, audio or video tapes, or computer floppy disks will **not** be accepted.

Proposals not meeting these requirements will be returned without review.

3.3 Phase 1 Proposal Format

3.3.1 Cover Sheet

Complete Section 9 "Cover Page" as page 1 of each copy of each proposal. **NO OTHER COVER WILL BE ACCEPTED.** Xerox copies are permitted.

3.3.2 Project Summary

Complete Section 9 "Project Summary" as page 2 of your proposal. The technical abstract should include a brief description of the problem or opportunity, the innovation, project objectives, and technical approach.

In summarizing anticipated results, include technical implications of the approach (for both Phase 1 and 2) and the potential commercial applications of the research. **The Project Summary of successful proposals will be published by DOC and, therefore, must not contain proprietary information.**

3.3.3 Technical Content

Beginning on page 3 of the proposal, include the following items with headings as shown:

(a) *Identification and Significance of the Problem or Opportunity.* Make a clear statement of the specific research problem or opportunity addressed, its innovativeness, commercial potential, and why it is important. Show how it applies to a specific subtopic in Section 8.

(b) *Phase 1 Technical Objectives*. State the specific objectives of the Phase 1 effort, including the technical questions it will try to answer, to determine the feasibility of the proposed approach.

(c) *Phase 1 Work Plan*. Include a detailed description of the Phase 1 R&D plan. The plan should indicate not only what will be done, but where it will be done, and how the R&D will be carried out. The methods planned to achieve each objective or task should be discussed in detail. **This section should be at least one-third of the proposal.**

(d) *Related Research or R&D*. Describe research or R&D that is directly related to the proposal, including any conducted by the principal investigator or by the proposer's firm. Describe how it relates to the proposed effort, and describe any planned coordination with outside sources. The purpose of this section is to persuade reviewers of the proposer's awareness of recent developments in the specific topic area.

(e) *Key Personnel and Bibliography of Related Work*. Identify key personnel involved in Phase 1, including their related education, experience, and publications. Where resumes are extensive, summaries that focus on the most relevant experience and publications are suggested. List all other commitments that key personnel have during the proposed period of contract performance.

(f) *Relationship with Future R&D*. Discuss the significance of the Phase 1 effort in providing a foundation for the Phase 2 R&D effort. Also state the anticipated results of the proposed approach, if Phases 1 and 2 of the project are successful.

(g) *Facilities and Equipment*. The conduct of advanced research may require the use of sophisticated instrumentation or computer facilities. The proposer should provide a detailed description of the availability and location of the facilities and equipment necessary to carry out Phase 1. If the use of Government owned facilities and/or equipment is necessary to

carry out Phase 1, the proposer should state their location, when required, and give details of arrangements made.

(h) *Consultants and Subcontracts*. The purpose of this section is to convince DOC that: (1) research assistance from outside the firm materially benefits the proposed effort, and (2) arrangements for such assistance are in place at the time the proposal is submitted.

Outside involvement in the project is encouraged where it strengthens the conduct of the research; such involvement is not a requirement of this solicitation.

1. Consultant - A person outside the firm, named in the proposal as contributing to the research. Must provide a signed statement confirming his/her availability, role in the project, and agreed consulting rate for participation in the project. This statement is part of the page count.

2. Subcontract - Similarly, where a subcontract is involved in the research, the subcontracting institution must furnish a letter signed by an appropriate official describing the programmatic arrangements and confirming its agreed participation in the research, with its proposed budget for this participation. This letter is part of the page count.

(i) *Potential Commercial Application and Follow-on Funding Commitment*. Describe in detail the commercial potential of the proposed research and how commercialization would be pursued.

(j) *Cooperative Research and Development Agreements (CRADA)*. State if the applicant is a current CRADA partner with DOC, or with any other federal agency, naming the agency, title of the CRADA, and any relationship with the proposed work.

(k) *Guest Researcher*. State if the applicant is a guest researcher at DOC, naming the sponsoring laboratory.

3.4 Equivalent Proposals or Awards

A firm may have received other SBIR awards or elected to submit essentially equivalent proposals under other SBIR program solicitations. In these cases, a statement **must**

follow the Technical Content section in the proposal indicating:

(a) the name and address of any agency to which a proposal was submitted or from which an SBIR award was received;

(b) the date of proposal submission or date of award;

(c) the title, number, and date of the SBIR program solicitation under which a proposal was submitted or award received;

(d) the title of the research project; and

(e) the name and title of the principal investigator for each proposal submitted or award received.

If no equivalent proposal is under consideration or equivalent award received, a statement to this effect **must** be included in this section.

3.5 Prior SBIR Phase 2 Awards

If a small business concern has received more than 15 Phase 2 awards from **all** Federal agencies in the prior 5 fiscal years, it must submit on a separate page, the names of awarding agencies, dates of awards, funding agreements numbers, amounts, topics or subtopic titles, follow-on agreements amounts, sources and dates of commitments, and current commercialization status for each Phase 2. This required information shall not be part of the page count limitation.

3.6 Proposed Budget

Complete the "SBIR Proposal Summary Budget" (Section 9) for the Phase 1 effort, and include it as the last page of the proposal. Some items of this form may not apply. Enough information should be provided to allow DOC to understand how the offeror plans to use the requested funds if the contract or grant is awarded. A complete cost breakdown should be provided setting forth base labor rates, proposed number of hours, overhead, G&A, and profit. A reasonable profit will be allowed. When proposing travel, set forth how many trips, number of people, labor categories, destination of travel, duration of trip, commercial air fare or mileage rate, per diem expenses, and purpose of travel. Budgets for travel funds must be justified and related to the needs of the project.

Where equipment is to be purchased, list each individual item with the corresponding cost. The inclusion of equipment will be carefully reviewed relative to need and appropriateness for the research proposed. Equipment is defined as an article of

nonexpendable, tangible property having a useful life of more than 1 year and an acquisition cost of $5,000 or more per unit. **Title to equipment will be vested with DOC, unless it is determined that transfer of title to the contractor would be more cost effective than recovery of the equipment.**

For a fee, specialized NIST/NOAA equipment and facilities may be made available. When these are needed, the proposal must identify the specific requirements and state the arrangements made with the appropriate NIST/NOAA manager.

For Phase 1, a minimum of two-thirds of the research and/or analytical effort must be performed by the proposing firm. The total cost for all consultant fees, facility leases, usage fees, and other subcontract or purchase agreements may not exceed one-third of the total contract. For Phase 2, one-half of the research and/or analytical effort must be performed by the proposing firm.

4.0 METHOD OF SELECTION AND EVALUATION CRITERIA

4.1 Introduction

All Phase 1 and 2 proposals will be evaluated on a competitive basis. Each Phase 1 proposal will be screened by DOC procurement staff to ensure that it meets the administrative requirements outlined in Section 4.2. Proposals that meet these requirements will be peer reviewed, undergo competition within each laboratory, and may also undergo a third round of competition across the agency.

4.2 Phase 1 Screening Criteria

To avoid misunderstanding, small businesses are cautioned that Phase 1 proposals not satisfying all the screening criteria shall be returned without peer review and shall be eliminated from consideration for contract or grant award. These proposals shall not be resubmitted (with or without revision) under this solicitation. All copies of such proposals failing the screening process shall be returned with a letter of notification. The screening criteria are:

(a) The proposing firm must qualify as a small business (Section 2.1). If it is a subsidiary of another firm, this limit applies to all employees under control of the parent organization.

(b) The Phase 1 proposal must meet **all** of the requirements stated in Section 3.

(c) The Phase 1 proposal must be limited to one subtopic and clearly address research for that subtopic.

(d) Phase 1 proposal budgets must not exceed $75,000 **(except subtopics with the suffix "SG", which are limited to $50,000),** including subcontract, indirect cost, and fee.

(e) **The project duration for the Phase 1 research must not exceed 6 months.**

(f) A minimum of two-thirds of expenditures under each Phase 1 project must be carried out by the proposing firm.

(g) The proposal must contain information sufficient to be peer reviewed as research.

4.3 Phase 1 Evaluation and Selection Criteria

Phase 1 proposals will be rated by NOAA and NIST scientists or engineers with equal consideration given to the following criteria, except for item (a), which will receive twice the value of any of the other items:

(a) The scientific and technical merit of the Phase 1 research plan and its relevance to the objectives, with special emphasis on its innovativeness and originality.

(b) Importance of the problem or opportunity and anticipated benefits of the proposed research to DOC, and the commercial potential, if successful.

(c) How well do the research objectives, if achieved, establish the feasibility of the proposed concept and justify a Phase 2 effort?

(d) Qualifications of the principal investigator(s), other key staff, and consultants, and the probable adequacy of available or obtainable instrumentation and facilities.

Technical reviewers will base their ratings on information contained in the proposal. It cannot be assumed that reviewers are acquainted with any experiments referred to, key individuals, or the firm.

Final award decisions will be made by DOC based upon ratings assigned by reviewers and consideration of other factors, including possible duplication of other research, the importance of the proposed research as it relates to DOC needs, and the availability of

funding. DOC may elect to fund several or none of the proposals received on the same subtopic.

Upon selection of a proposal for a Phase 1 award, DOC reserves the right to negotiate the amount. A Phase 1 award shall be made at an amount determined by DOC to be reasonable.

4.4 Phase 2 Evaluation and Selection Criteria

The Phase 2 proposal will undergo DOC and/or external peer review for the purpose of determining overall technical or scientific merit. Each of the following evaluation criteria will receive approximately equal weight, except for item (a), which will receive twice the value of any of the other items:

(a) The scientific and technical merit with emphasis on innovation and originality.

(b) Degree to which the Phase 1 objectives were met.

(c) The commercial potential of the proposal as evidenced by: a) a record of commercialization, b) the existence of Phase 2 funding commitments from non-SBIR sources, c) existence of Phase 3 follow-on commitments, and d) the presence of other indications of commercial potential of the research.

(d) The adequacy of the Phase 2 objectives to meet the problem or opportunity.

(e) The qualifications of the principal investigator and other key personnel to carry out the proposed work.

Upon selection of a proposal for Phase 2 award, DOC reserves the right to negotiate the amount. Phase 2 awards will be made only at amounts determined by DOC to be reasonable.

4.5 Release of Proposal Review Information

After final award decisions have been announced, the technical evaluations of a proposal will be provided to the proposer only upon written request and for a period not to exceed 90 days. The identity of the reviewers will not be disclosed.

5.0 CONSIDERATIONS

5.1 Awards

Contingent upon availability of funds, DOC anticipates making about **42** Phase 1 firm-fixed-price contracts or grants of no more than **$75,000** each (except for subtopics with the suffix “SG”, which are limited to $50,000). Of these, approximately **12** will be made

by the National Oceanic and Atmospheric Administration (NOAA) and approximately **30** by the National Institute of Standards and Technology (NIST). Performance period shall be no more than 6 months beginning on the contract start date.

Historically, DOC has funded five to ten percent of the Phase 1 proposals submitted.

Phase 2 awards shall be for no more than **$300,000** (except subtopics with an "SG" suffix, which are limited to $200,000). The period of performance in Phase 2 will depend upon the scope of the research, but should not exceed 24 months.

It is anticipated that **approximately one-third of the Phase 1 awardees will receive Phase 2 awards,** depending upon availability of funds. To provide for an in-depth review of the Phase 1 final report and the Phase 2 proposal and commercialization plan, Phase 2 awards will be made approximately 7 months after the completion of Phase 1.

This solicitation does not obligate DOC to make any awards under either Phase 1 or Phase 2. Futhermore, DOC is not responsible for any monies expended by the proposer before award of any contract or grant resulting from this solicitation.

5.2 Reports

Seven copies of a final report on the Phase 1 project shall be submitted to DOC within 30 calendar days after completion of the Phase 1 research. The final report shall include a single-page project summary as the first page, identifying the purpose of the research, and giving a brief description of the research carried out, the research findings or results, and the commercial applications of the research in a final paragraph. The balance of the report should indicate in detail the research objectives, research work carried out, results obtained, and estimates of technical feasibility.

All final reports must carry an acknowledgment on the cover page such as: "This material is based upon work supported by the Department of Commerce under contract or grant number _____. Any opinions, findings, or conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the Department of Commerce."

5.3 Payment Schedule

The specific payment schedule (including payment amounts) for each contract or grant will be incorporated into the contract or grant upon completion of negotiations between the Government and the successful Phase 1 or Phase 2 contractor or grantee.

5.4 Proprietary Information, Inventions, and Patents

5.4.1 Limited Rights Information and Data

Information contained in unsuccessful proposals will remain the property of the proposer. Any proposal which is funded will not be made available to the public, except for the "Project Summary" page.

The inclusion of proprietary information is discouraged unless it is necessary for the proper evaluation of the proposal.

Proprietary information submitted to DOC will be treated in confidence, to the extent permitted by law, if it is confined to a separate page or pages and marked with a legend similar to this:

> "Following is proprietary information which (name of proposing firm) requests not be released to persons outside the Government, except for purposes of evaluation."

Any other legend may be unacceptable to the Department of Commerce and may constitute grounds for return of the proposal without further consideration. Without assuming any liability for inadvertent disclosure, DOC will limit dissemination of such information to its employees and, where necessary for evaluation, to outside reviewers on a confidential basis.

Since technical reports by the principal investigator or project director may eventually be made available to the public, such reports shall not contain any language limiting their use other than for SBIR data as described below.

5.4.2 Copyrights

The contractor or grantee may normally establish claim to copyright any written material first produced in the performance of an SBIR contract or grant. If a claim to copyright is made, the contractor or grantee shall affix the applicable copyright notice of 17 U.S.C. 401 or 402 and acknowledgment of Government sponsorship (including contract or grant number) to the material when delivered to the Government, as well as when the written material or data are published or deposited for registration as a published work in the U.S. Copyright Office. For other than computer software, the contractor or grantee gives to the Government, and others acting on its behalf, a paid-up, nonexclusive, irrevocable, worldwide license to reproduce, prepare derivative works, distribute copies to the public, and perform publicly and display publicly, by or on

behalf of the Government. For computer software, the contractor or grantee gives to the Government, and others acting on its behalf, a paid-up, nonexclusive, irrevocable, worldwide license for all such computer software to reproduce, prepare derivative works, and perform publicly and display publicly, by or on behalf of the Government.

5.4.3 Data Rights

Except for copyrighted data discussed above, the Government shall normally have unlimited rights in:

(a) data specifically identified in the SBIR contract or grant as data to be delivered without restriction;

(b) form, fit, and function data delivered under the contract or grant;

(c) data delivered under the contract or grant that constitute manuals or instructions and training material for installation, operation, or routine maintenance and repair of items, components, or processes delivered or furnished for use under the contract or grant; and

(d) all other data delivered under the contract or grant unless identified as SBIR data. According to Federal Acquisition Regulation 52.227-20, Rights and Data - SBIR Program (March 1994), the contractor or grantee is authorized to affix the following "SBIR Rights Notice" to SBIR data delivered under the contract or grant:

SBIR RIGHTS NOTICE

These SBIR data are furnished with SBIR rights under Contract or Grant No. _____ (and subcontract _____ , if appropriate). For a period of 4 years after acceptance of all items to be delivered under this contract or grant, the Government agrees to use these data for Government purposes only, and they shall not be disclosed outside the Government (including disclosure for procurement purposes) during such period without permission of the contractor or grantee, except that, subject to the forgoing use and use by support contractors. After the aforesaid 4-year period, the Government has a royalty-

free license to use, and to authorize others to use on its behalf, these data for Government purposes, but is relieved of all disclosure prohibitions and assumes no liability for unauthorized use of these data by third parties. This Notice shall be affixed to any reproductions of these data, in whole or in part.

(END OF NOTICE)

The Government's sole obligation with respect to any properly identified SBIR data shall be as set forth in this paragraph above.

5.4.4 Patents

Small business firms normally may retain the worldwide patent rights to any invention made with DOC support. DOC receives a royalty-free license for Federal Government use, reserves the right to require the patent holder to license others in certain circumstances, and requires that anyone exclusively licensed to sell the invention in the United States must normally manufacture it domestically. To the extent authorized by P.L. 102-564, DOC will not make public any information disclosing a DOC-supported invention for a 4-year period to allow the contractor or grantee a reasonable time to pursue a patent.

5.5 Awardee Commitments

On award of a contract or grant, the contractor or grantee will be required to make certain legal commitments. The outline that follows illustrates the types of provisions that will be included in the Phase 1 contract or grant.

(a) *Standards of Work*. Work performed under the contract or grant must conform to high professional standards.

(b) *Inspection of Work*. Work performed under the contract or grant is subject to Government inspection and evaluation at all reasonable times.

(c) *Examination of Records*. The Comptroller General (or a duly authorized representative) shall have the right to examine pertinent records of the contractor or grantee involving transactions related to this contract or grant.

(d) *Default*. The Government may terminate the agreement if the contractor fails to perform the work contracted. A grantee must provide its best effort to complete the work.

(e) *Termination for Convenience*. The contract or grant may be terminated at any time by the Government if it deems termination to be in the best interest, in which case the contractor or grantee will be compensated for work performed and for reasonable termination costs.

(f) *Disputes*. Any dispute concerning the contract or grant, which cannot be resolved by agreement, shall be decided by the Contracting or Grants Officer with right to appeal.

(g) *Contract or Grant Work Hours*. The contractor or grantee cannot require an employee to work more than 8 hours a day or 40 hours a week, unless the employee is compensated accordingly (i.e., receives overtime pay).

(h) *Equal Opportunity*. The contractor or grantee will not discriminate against any employee or applicant for employment because of race, color, religion, sex, or national origin.

(i) *Affirmative Action for Veterans*. The contractor or grantee will not discriminate against any employee or applicant for employment because he or she is a disabled veteran of the Vietnam era.

(j) *Affirmative Action for the Handicapped*. The contractor or grantee will not discriminate against any employee or applicant for employment because he or she is physically or mentally handicapped.

(k) *Officials Not to Benefit*. No member of or delegate to Congress shall benefit from any SBIR contract or grant.

(l) *Covenant Against Contingent Fees*. No person or agency has been employed to solicit or secure the contract or grant upon an understanding for compensation, except bona fide employees or commercial agencies maintained by the contractor or grantee for the purpose of securing business.

(m) *Gratuities*. The contract or grant may be terminated by the Government if any gratuity has been offered to any representative of the Government to secure the contract.

(n) *Patent Infringement*. The contractor or grantee shall report each notice or claim of patent infringement based on the performance of the contract.

(o) *American-Made Equipment and Products*. When purchasing either equipment or a product with funds provided through the contract or grant, purchase only American-made equipment and products, to the extent possible in keeping with the overall research needs of the project.

5.6 Additional Information

(a) Projects--The responsibility for the performance of the principal investigator, and other employees or consultants who carry out the proposed work, lies with the management of the organization receiving an award.

(b) Organizational Information--Before award of an SBIR contract or grant, the Government may request the proposer to submit certain organizational, management, personnel, and financial information to assure responsibility of the proposer.

(c) **Duplicate Awards--If an award is made under this solicitation, the contractor or grantee will be required to certify that he or she has not previously been, nor is currently being, paid for essentially equivalent work by any agency of the Federal Government. Severe penalties may result from such actions.**

This program solicitation is intended for informational purposes and reflects current planning. If there is any inconsistency between the information contained herein and the terms of any resulting SBIR contract or grant, the terms of the contract or grant are controlling.

6.0 SUBMISSION OF PROPOSALS

6.1 Deadline for Proposals

Deadline for Phase 1 proposal receipt (7 copies) at the Department of Commerce Contract Administration Branch is noon on January 14, 1998.

DOC assumes no responsibility for evaluating proposals received after the stated deadline or that do not adhere to the other requirements of this solicitation (see checklist on p. 114). Such proposals may be returned to the proposer without review.

Federal Acquisition Regulations (FAR 52.215-10) regarding late proposals shall apply.

Phase 2 proposals are due at about the same time as Phase 1 final reports - 7 months after commencement of the Phase 1 contract (late June 1998).

Proposers are cautioned to be careful of unforeseen delays which can cause late arrival of proposals at DOC, resulting in them not being included in the evaluation procedures. No information on the status of proposals under scientific/technical evaluation will be available until formal notification is made in June 1998.

6.2 Proposal Submission

Proposals (7 copies) should only be addressed to:

ATTN: SBIR Proposals
U.S. Department of Commerce, NOAA
Contract Administration Branch, Code OFA513
1305 East-West Highway, SSMC4, Station 7523
Silver Spring, Maryland 20910
Telephone: (301) 713-0829

For local delivery, the Contract Administration Branch is located near the intersection of East-West Highway and Colesville Road, near the Silver Spring Metro stop.

Acknowledgment of receipt of a proposal by DOC will be made by **mail only**. All correspondence relating to proposals must cite the specific **proposal number** identified on the acknowledgment letter and be sent to the above address.

(a) **Packaging--Secure packaging is mandatory. The DOC cannot process proposals damaged in transit. All 7 copies of the proposal must be sent in the same package. Do not send separate "information copies," or several packages containing parts of a single proposal, or two packages of 7 copies of the same proposal. The top copy must be signed as an original by the principal investigator and the corporate official. Other copies may be photocopies.**

(b) Bindings--**Do not use special bindings or covers.** Staple the pages in the upper left hand corner of each proposal. Separation or loss of proposal pages cannot be the responsibility of DOC.

6.3 Warning

While it is permissible, with proper notification to DOC, to submit identical or essentially equivalent proposals for consideration under numerous Federal program solicitations, it is unlawful to enter into contracts or grants requiring essentially equivalent effort. If there is any question concerning this, it must be disclosed to the soliciting agency or agencies before award.

7.0 SCIENTIFIC AND TECHNICAL INFORMATION ASSISTANCE

7.1 General Information

The following organizations may be sources for providing technology search and/or document services and may be contacted directly:

NOAA Library
1315 East-West Highway
Second Floor, SSMC3
Silver Spring, MD 20910
(301) 713-2600

NIST Library
Admin. Bldg., Room E106
Gaithersburg, MD 20899
(301) 975-3052

National Technology Transfer Center (NTTC)
316 Washington Avenue
Wheeling, WV 26003
(304) 243-2520

Mid-Atlantic Technology Applications Center
823 William Pitt Union
University of Pittsburgh
Pittsburgh, PA 15260
(412) 648-7000

Southern Technology Applications Center
One Progress Blvd.
Box 24
Alachua, FL 32615
(904) 462-3913

UK Technology Applications Center
University of Kentucky
109 Kinkead Hall
Lexington, KY 40506-0057
(606) 257-6322

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
(703) 487-4600

NERAC, Inc.
One Technology Drive
Tolland, CT 06084
(203) 872-7000

Small Business Innovation Center
Advanced Technology Center of Southeastern Pennsylvania
3624 Market Street
Philadelphia, PA 19104
(215) 382-0380

NASA Far West Regional Technology Transfer Center
University of Southern California
3716 South Hope Street, #200
Los Angeles, CA 90007
(213) 743-2353

7.2 Oceanography and Marine Science

Scientific information in the areas of oceanography and marine science may be obtained from the following organizations:

University of Alaska
P.O. Box 755040
Fairbanks, AK 99775
907/474-7086

University of California-San Diego
9500 Gilman Drive
LaJolla, CA 92093
619/534-4440

Hancock Institute for Marine Studies
University Park
Los Angeles, CA 90089
213/740-1961

University of Connecticut
1084 Shennecossett Road
Groton, CT 06340
203/445-3457

University of Delaware
Robinson Hall, Rm 111
Newark, DE 19716
302/831-2841

University of Florida
Building 803
Gainesville, FL 32611
904/392-5870

University of Georgia
Ecology Building
Athens, GA 30602
706/542-6009

University of Hawaii
1000 Pope Road, Rm. 223
Honolulu, HI 96822
808/956-7031

University of Illinois
65 Mumford Hall
1301 W. Gregory Drive
Urbana, IL 61801
217/333-9448

Purdue University
1159 Forestry Building
W. Lafayette, IN 47907
317/494-3573

Louisiana State University
128 Wetland Resources
Baton Rouge, LA 70803
504/388-6710

University of Maine
14 Coburn Hall
Orono, ME 04469- 0114
207/581-1436

University of Maryland
0112 Skinner Hall
College Park, MD 20742
301/405-6371

Massachusetts Institute of Technology
Bldg. E38, Room 330
77 Massachusetts Avenue
Cambridge, MA 02139
617/253-7131

Woods Hole Oceanographic Institution
CRL 209
Woods Hole, MA 02543
508/457-2000 ext. 2665

University of Michigan
4107 I.S.T. Building
2200 Bonisteel Blvd.
Ann Arbor, MI 48109
313/763-1437

University of Minnesota
2305 East 5th Street
Duluth, MN 55812
218/726-8106

MS-AL Sea Grant Consortium
P.O. Box 7000
703 East Beach Drive
Ocean Springs, MS 39564
601/875-9341

University of New Hampshire
Ocean Process Analysis Lab.
142 Morse Hall
Durham, NH 03824
603/862-3505

NJ Marine Sciences Consortium
Building No. 22
Ft. Hancock, NJ 07732
908/872-1300

State University of New York
115 Nassau Hall
Stony Brook, NY 11794
516/632-6905

North Carolina State University
Box 8605
Raleigh, NC 27695
919/515-1454

Ohio State University
1541 Research center
1314 Kinnear Road
Columbus, OH 43212
614/292-8949

Oregon State University
Administrative Services
Corvallis, OR 97331
503/737-3396

University of Puerto Rico
Department of Marine Science
P.O. Box 5000
Mayaguez, PR 00681
809/832-3585

University of Rhode Island
Marine Resources Bldg.
Narragansett Bay Campus
Narragansett, RI 02882
401/792-6800

South Carolina Sea Grant Consortium
287 Meeting Street
Charleston, SC 29401
803/727-2078

Texas A&M University
1716 Briarcrest Drive
Suite 702
Bryan, TX 77802
409/845-3854

Virginia Graduate Marine Science Consortium
Madison House 170
Rugby Road
Charlottesville, VA 22903
804/924-5965

University of Washington
HG-30
3716 Brooklyn Ave, N.E.
Seattle, WA 98105-6716
206/543-6600

University of Wisconsin-Madison
1800 University Avenue
Madison, WI 53705
608/262-0905

8.0 TECHNICAL TOPICS

The subtopics in sections 8.1 through 8.5 are from the National Oceanic and Atmospheric Administration (NOAA). Approximately 12 awards will be made on these subtopics.

8.1 NOAA TOPIC: ATMOSPHERIC AND HYDROLOGICAL SCIENCES

8.1.1A SUBTOPIC: Microwave Remote Sensing of the Ocean Surface Wind Vector Using Passive Polarimetry

Investigators over the last several years have shown that it is possible to measure the ocean surface wind vector using a polarimetric microwave radiometer system. The ocean surface wind vector is an important environmental parameter for research and operational marine forecasting. A compact system is sought to deploy on the NOAA WP-3D aircraft during hurricane reconnaissance flights and other flights of opportunity. Since other instrumentation typically occupies all the downward looking ports along the aircraft fuselage, integration into a modified WP-3D fuel pod is necessary. Modification of the pod would include any necessary radome and mounting structures for the radiometer system. The polarimetric microwave radiometer should be capable of scanning at least +/-70 degrees off of the aircraft heading at a fixed incidence angle between 45 to 65 degrees from nadir. The radiometer system will have to account for atmospheric effects such as water vapor and precipitation for wind retrievals in the desired range of 0-70 meters/second. A wind speed and direction retrieval accuracy of +/-2 meters/second and +/-20 degrees is required. A spatial resolution on the ocean surface of approximately 1.5 km at an altitude of 6,000m (about 20,000 feet) is desired at an incidence angle of 55 degrees. The ability to report the winds in real-time should also be considered in the system design to allow the relaying of information to hurricane forecasters during hurricane reconnaissance flights. A quantitative measure of rain rate is also desired. The entire system should be as compact and self-contained as possible to minimize potential interference with other equipment. Existing wiring in the aircraft wing should be utilized for necessary interfacing between the pod and the main cabin.

8.1.2A SUBTOPIC: Site Specific Analysis and Display of Tornado Hazard Potential

The NWS maintains a data base containing track characteristics and intensity data for tornados over the contiguous United States since 1950. These data have been used to estimate the tornado hazard at various points across the country. Such estimates have a wide variety of engineering, architectural, actuarial, and regulatory applications. To

get full use of these data, a need exists for a means of quickly and accurately analyzing and displaying up-to-date site-specific tornado statistics. A PC software package to interactively perform such site specific hazard estimates is desired. The software output should include local or regional maps of tornado tracks (sorted by intensity), graphs of temporal and spacial distributions of past tornado events around the point of interest, and hazard estimates in terms of probabilities or reoccurrence intervals.

8.1.3A SUBTOPIC: Laser for an Unattended Atmospheric Water Vapor Profiler

The NOAA Environmental Technology Laboratory is currently building a compact, low-cost and eye-safe Differential Absorption Lidar (DIAL) to measure water vapor profiles in the lower troposphere with moderate spatial and temporal resolution. Such measurements are needed for the improvement of weather forecast and climate models. A low-cost, low-maintenance lidar system is desirable because it permits affordable unattended deployment of multiple lidars for regional studies of moisture transport (fluxes). The current lidar design uses a high pulse repetition frequency (prf) amplified diode laser with a maximum average power output of ~10 mW. Water vapor measurements with greatly improved time resolution and signal-to-noise ratio could be obtained with a 10 to 30 times more powerful laser. Proposals are desired for a higher power infrared solid state laser for the DIAL transmitter with the following capabilities. The laser should have a prf of 6-10 kHz, pulse durations of 20 to 200 ns, no prepulse light, a TEM00 mode, and good efficiency and stability. For DIAL, it is essential the laser can be locked to a specific wavelength with single frequency operation (a line width of several hundred MHZ). For the water vapor DIAL, the laser should be quickly tunable on and off one or more good water vapor lines in one of the following wavelength regions: 716-735 nm, 692-703 nm, 811-837 nm, or 892-986 nm.

8.1.4A SUBTOPIC: Automated Airborne Measurements of Atmospheric Chemical Species

The NOAA Office of Global Programs has broad interest in the measurement of atmospheric chemical composition variables for use in Federal and private sector Climate and Global Change (C&GC) studies. A network of surface-based chemical composition measurements exists, and there is a fledgling capability to observe selected chemical species globally by satellite, but the space/time resolution of these systems is too poor and the error bars of the satellite measurements are still too large. Examples of measurements needed include greater time/space scale coverage of atmospheric aerosols and atmospheric chemical composition (methane, ozone, carbon dioxide) profiles. Commercial aircraft have been identified as promising platforms for making global measurements to complement in-situ data and help continuously

calibrate satellite data over the four dimensions of space and time. Proposals are sought that suggest innovative approaches to the adaptation of proven automated, chemical composition species measurement techniques for use on such aircraft. Systems should provide accurate measurements of one or more of the variables listed above. In preparing proposals, investigators must remember that commercial aircraft require extremely small sensors, because space and weight are at a premium; therefore, only proposals that take this requirement into account should be submitted.

8.1.5A SUBTOPIC: Ultraviolet Laser Source for an Unattended Ozone Lidar

The NOAA Environmental Technology Laboratory has developed lidar systems for measurement of tropospheric ozone and is applying them to studies on urban and regional pollution. These systems are ultraviolet differential absorption lidars being used in ground-based and airborne applications. However, both require significant operator involvement and are physically large. In order to make this type of system more widely useful and less expensive to deploy, it would be desirable to build compact, high-reliability, unattended units. These units could then be set up in and around the pollution areas of interest for longer term monitoring, or more easily integrated into an airborne platform. To this end, we are seeking innovative developments in ultraviolet laser sources that could be applied to these systems. The general nature of the lasers sought may be compared to the diode pumped solid state lasers currently available for other wavelengths. The laser wavelengths needed for this type of lidar are in the 260-360 nm range. A minimum of two wavelengths are needed in the lower half of this range, with it being highly desirable to have one additional line near the upper end of the range. A rapidly tunable laser or several discrete operating lines would be preferred over having multiple sources. The laser output power should be in the 100 mW range or higher. Higher pulse energies are needed at shorter wavelengths than at longer wavelengths due to absorption by the atmospheric ozone. Short pulse durations of 20 to 200 ns and high pulse repetition rates would allow more flexibility in the lidar applications.

8.1.6A SUBTOPIC: A Directional Scanning Spectral Sky Radiance Mapper

One of the perplexing uncertainties facing atmospheric radiation research scientists today is the spatial distribution of atmospheric solar radiance, ranging from the UV through the near infrared. A very serious debate that has gained scientific attention is

the disparity between clear-sky theoretical calculations of solar transmission and what is observed. The range of the differences is approximately 30 to 50 W/m2. Although the solar and terrestrial radiation bands are somewhat separate, the solar irradiance difference by far exceeds the amount of change in IR irradiance expected to occur from trace gas warming. The solar transmission models do not explicitly calculate the sky radiance and, therefore, may be a source of uncertainty in the theoretical calculations. There exist sophisticated theoretical models that do explicitly calculate the sky radiance, but measurements for confirmation are rare, and for the most part, non-existent in various field investigations.

A secondary problem that the UV community has been struggling with is the determination of the error in the calibration of UV instruments. All hemispheric irradiance collectors suffer from what is called cosine error. If this error is not taken into account when using UV spectral radiometers, it propagates into the calibration of field instruments. The solution to this problem is the application of sky radiance measurements to correct for the irradiance collector's cosine error during a calibration episode. So far, we have identified a UV cosine error in the Brewer spectral irradiance as large as 7% which is intolerable (in some cases, it could be larger) since the standard lamp error is only on the order of < 2%, and this error is often misunderstood as the only instrumental error. Some instruments are much worse. With NOAA's responsibility as the Central UV Calibration Facility which characterizes and calibrates UV instruments in U.S. Government agency networks, it becomes obviously imperative that the best procedures be used.

The sky radiance mapper that would satisfy NOAA's needs should at least be able to supply maps of sky radiance in 10 wavelength bands (more would be desirable), in the UV and visible wavelengths (from ~0.3-2um, filters are O.K.) as a function of azimuth and elevation angle every 30 degrees in azimuth and elevation angle (the angular requirements should be selectable). The full viewing angle should be on the order of 1 degree. It would be desirable to acquire a complete scan of angle and irradiance in approximately three minutes or less. All parameters (e.g. time, angles, wavelengths, radiance, etc.) should be recorded on electronic media and the pointing of the instrument should be completely programmable and automated. One can expect a very large range of atmospheric radiance signal when viewing a clear sky compared to one with broken clouds, especially in the near IR. This range is also dependent on solar zenith angle, from high noon to near twilight, although practical considerations must be given, because physical requirements and instrument costs are indeed to be taken into account. A guess at the range is about 4 to 5 orders of magnitude.

The first phase should be a design study and a simple testing of components. The study should be focused on a practical compromise between the wavelength, range of sky radiances, solar zenith angle, and reasonable range of instrument sensitivity. It will be necessary to perform a brief study to determine the range of sky radiance conditions that can be expected.

A suggested reference is:

Blumthaler, J. Grobner, M. Huber, and W. Ambach. 1996. Measuring spectral and spatial variations of UVA and UVB sky radiance. Geophys. Res. Lett., vol 23, 547-550.

8.1.7A SUBTOPIC: Rotating Arm Attachment for Standard Pyranometers

Understanding the effect of clouds on the surface radiative energy budget is of critical importance in forecast model and satellite retrieval algorithm development. Techniques have been developed that use measurements of diffuse and total hemispheric solar (shortwave) irradiance to determine the cloud effect on the downwelling solar irradiance. However, current tracking-based systems for component solar measurements generally require periodic adjustment and maintenance, precluding deployment in remote locations. These tracker systems are also relatively expensive, thus deployment is also limited by economics. There are many sites, however, that already measure the downwelling solar irradiance using standard pyranometers (for example the Eppley model PSP). If an inexpensive rotating shading arm system can be attached to existing pyranometers, the solar components can be measured cost-effectively at these locations. This idea was investigated briefly at Penn State University with encouraging results. A rotating arm driven by a stepper motor was attached to an Eppley PSP. This system used the pyranometer response as the arm was rapidly moving through the upper hemisphere to "find" the sun and accurately position the arm, thus allowing the arm itself to be the minimum width required to block the pyranometer detector, and allowing error in system alignment (More information is available via the World Wide Web at http://www.srrb.noaa.gov/~long/publctns/publctns.htm). Due to the detector response time, a continuously rotating arm is not feasible for standard thermopile pyranometers, thus some type of arm positioning and holding system is necessary. Other systems have been developed that use faster responding silicone-based detectors (for example Licor pyranometers), which allows for constantly rotating arms. However, these detectors have different spectral ranges and responses from the standard thermopile pyranometers, and thus produce irradiance values different from the thermopile instruments under clear or cloudy skies (depending on how they were calibrated). The system developed at Penn State required a PC to run the arm and log the data, which increased the cost over what current technology could make possible. There are circuit

boards and data logging systems that are currently available and could be adapted to the task for far less cost. In addition, weather-hardened stepper motor and arm systems are available, such as those used for the Multi-Frequency Rotating Shadowband Radiometer developed at the State University of New York by Harrison and Michalsky. The innovation sought here is to integrate these commercially available parts to develop an inexpensive commercial rotating arm attachment system. Should an inexpensive rotating arm attachment for standard pyranometers as described above be developed, then cost-effective solar component measurements become feasible at far more sites than is currently possible, with the same spectral range and response as current standard instrumentation.

References:

Long, C. N. 1996. Surface Radiative Energy Budget and Cloud Forcing: Results from TOGA COARE and Techniques for Identifying and Calculating Clear Sky Irradiance. Doctoral Thesis, Penn State Univ., 193pp.

Long, C. N., C. F. Pavloski, and T. P. Ackerman 1996. A Rotating Shadow Arm Broadband Solar Radiometer: Instrument Design and Concept Verification Using ARM SGP Radiometer Measurements. Proc. 6th Atmospheric Radiation Measurement Science Team Meeting, Mar 4-7, 1996, San Antonio, Texas.

8.1.8A SUBTOPIC: X-Ray and Extreme Ultraviolet (EUV) Technologies for Solar Observations

Recent developments in solid state detectors for X-ray and EUV wavelengths have provided a technology from which light-weight, low-cost instruments for space-based observations have been built. These solid-state silicon diode detectors are extremely stable, and provide highly calibratable measurements for long periods of time. NOAA's Space Environment Center is starting to apply this technology to operational observations of X-ray and Extreme Ultraviolet emissions from the sun. These observations are used by SEC solar forecasters to identify the timing and magnitude of solar events and for estimating energy deposition in the upper atmosphere. Further refinements in detector technology, spectral dispersion, and spectrometric measurement techniques are desired. Specifically, methods of measuring the solar spectrum from 0.1 to 1000 Angstroms are required with moderate spectral resolution and over the large range of energies typically found in the solar spectrum. The instrumentation will also have to be robust, as it will be exposed to the radiation environment of geosynchronous orbit.

8.1.9A SUBTOPIC: Satellite Communications for Global Drifting Buoy Arrays

NOAA maintains a global array of low-cost drifting buoys for sea surface temperature, ocean current, atmospheric pressure and other meteorological observations. Data are used internationally for operational forecasts and model verifications. A variety of Low Earth Orbiting satellite (LEOs) constellations (NOAA/Argos, Orbcomm, Iridium, etc.) are now in, or will soon achieve, operational status. Potential benefits to be obtained from these new satellite systems include send and receive error-free communications, near real-time data transmissions, and reduced costs. Proposals are being sought for the identification of the most applicable LEOS system for drifter data communication, and subsequently for drifter construction and validation of data transmission. Data flow should include distribution onto the Global Telecommunications System (GTS). Emphasis should lie on the rapid, economic delivery of relatively short data records from low power transmitters. Existing drifter construction and operation are described in the World Meteorological Organization (WMO) Data Buoy Cooperation Panel (DBCP) Technical Document #4, available from the DBCP Technical Coordinator (email Etienne Charpentier at charpentier@cls.cnes.fr). A summary of existing and planned LEOS can be found in the report of the 12th DBCP meeting (October 1996) also available from the DBCP Technical Coordinator. Additional drifter information is available at the Global Drifter Center web site: http://www.aoml.noaa.gov/phod/dac/gdc.html.

8.2 NOAA TOPIC: OCEAN OBSERVATION SYSTEMS

8.2.1A SUBTOPIC: Operational Ocean Instrumentation, Measurement, and Data Assimilation Systems

Development of operational ocean instrumentation, measurement, and data assimilation systems are sought to support a wide range of NOAA 's National Ocean Service operational activities, such as current and water level measurement and prediction, wave forecasting, and marine pollution monitoring. These developments usually include all components of the entire monitoring system: sensing, data acquisition, and transmission. Data processing and analysis using innovative techniques will also be considered. The developments are not limited to any one type of platform (i.e., ship, towed system, buoy, airplane, satellite, etc.), and can be in-situ or remote, reusable or expendable. NOAA emphasizes systems which can be operated in an unattended mode. Where personnel are needed, use of only minimal skill levels is advantageous. If practical, these systems should provide near real-time data transmissions. Data transmissions via satellite and general purpose computer systems are used in NOAA to receive and process data. High reliability, known accuracy, and

cost effectiveness are important design considerations. The parameters of interest are comprehensive, including: physical, chemical, and biological properties of the coastal ocean environment; pollutants; and overlying atmospheric parameters. There is a special interest in parameters needed for the Coastal Ocean Forecast System (COFS). COFS provides marine environmental information in support of safe navigation, safe transportation of hazardous materials, economic benefits to marine commerce, and management of marine resources.

Of particular interest this year are proposals related to:

a) An alternative to the present NOAA primary water level sensor which uses an air acoustic transducer and sounding tube/protective well method. The sensor determines water level from the travel time of acoustic pulses to the water surface and return. There are several disadvantages associated with the tube/well subsystem. These include: the temperature gradient inside the well, marine fouling, attenuation of high frequency water level signals, and the high cost of installation and maintenance. NOAA is interested in investigating alternative, non-remote sensing technologies which do not require a sounding tube, such as laser, ultrasonic, or microwave ranging. The performance of the alternate sensor should improve upon the present accuracy of 9mm; resolution of 3 mm; range up to 10m; and sampling rate up to 4 samples per second.

b) Remote mapping of currents in the horizontal plane - Narrow-beam acoustic current profiler, or comparable technology, for remotely measuring the spatial current distribution in a horizontal plane near the mid-depth of a navigation waterway (harbors, bays, and river inlets) is sought. The sensor may be mounted on underwater structures such as piers, pilings, channel walls, or similar structures. The measurement should have a range of 400 meters (in water depth of 15 meters), and near-real time reporting capability. The ability to detect cross-channel velocity variations (flow deflections, current shears and eddies) is important.

c) Data Assimilation Systems - Algorithms and software for real-time objective analysis and gridding of data sets are needed for assimilation into hydrodynamic, numerical models for initialization, forcing, and evaluation of nowcasts and forecasts in coastal and estuarine models. The NOAA COFS system requires real-time realizations of surface meteorological and oceanographic fields for initialization, driving, and verification of their model nowcasts and forecasts of currents, water levels, temperature, and salinity. The data fields would need to be made available in a workstation or mainframe computer environment where the models would be running operationally.

8.2.2A SUBTOPIC: Hydrographic Data Acquisition and Data Processing

NOAA's National Ocean Service is seeking to improve the efficiency and effectiveness of its hydrographic operations. The request is for the development of software and algorithm solutions to problems of data acquisition and data processing. This does not, however, preclude solutions that are primarily hardware in nature. Of particular interest are: a) the blending of bathymetric data and acoustic imagery; b) improved data editing techniques which utilize both the acoustic backscatter strength and slant range time of flight on the several beams of a multibeam bathymetric sonar; c) efficient 3-D visualization of large fields of spatial data; and d) online tools for assessing/assigning quality parameters to bathymetric data as a function of nadir angle and natural variability of the local bathymetry.

8.2.3A SUBTOPIC: *In Situ* Chemical Analyzer

A requirement exists for developing *in situ* chemical analyzers that can be used to map or monitor chemical anomalies using continuous near real-time detection and data analysis. A system complete with chemical analyzer and data logger must be self contained so that it can be deployed by an underwater vehicle, mounted on a mooring, or used as a survey tool in concert with an underwater vehicle. This self-contained system should be developed for up to one-year deployments and have additional electronic ports for data from other sensors (e.g. temperature) to be synchronized with the chemical data. Problems associated with fouling and mineral precipitation should be considered.

8.2.4A SUBTOPIC: Improved Airborne Microwave Remote Sensing of Sea Surface Salinity

The proof-of-concept of airborne microwave sea surface salinity imaging measurements was successfully demonstrated in the mid-l990's with a low frequency microwave radiometer system operating in the 1.43GHz region. Using comparable systems relatively accurate surface salinity measurements have been obtained. Experience with these systems have suggested many improvements might be made which are achievable and affordable using the latest microwave technology advances. Better aerodynamics and reduced weight are needed to make an improved system deployable on a wide variety of small to medium size aircraft. These objectives could be achieved through improved packaging and utilization of newer antenna and antenna feed technologies. Improved calibration stability and reduced electrical requirements are very desirable, which might be achieved through an advanced thermal control subsystem. Improved thermal control and better aerodynamics are needed to allow the system to be deployed on higher altitude and faster (up to 300 knots) aircraft.

Improved system sensitivity and reduced receiver size could be achieved by using the latest low noise microwave amplifiers and low loss microwave control components. To improve sea surface salinity retrieval accuracy and to add sea surface temperature mapping as an ancillary capability, a scanning infrared sensor should be part of the system package. Other small-size, low cost auxiliary sensors are sought for deployment with the salinity mapper system to enhance its performance. These could include improved GPS receivers and aircraft pitch and yaw sensors. Software needs include: (1) improved salinity algorithms, (2) real time display of retrieved salinity and sea surface temperature using false-color images, and (3) improved user interface which might utilize WINDOWS GUL.

Reference:

Goodberlet, Mark, et al. Microwave Remote Sensing of Coastal Zone Salinity. Journal of Coastal Research, vol 13, no. 2, pp.363-372, Spring 1997.

8.3 NOAA TOPIC: LIVING MARINE RESOURCES

8.3.1A SUBTOPIC: Rapid, Sensitive, Non-Lethal Method for the Identification of Bacterial Pathogens of Salmonids

The objective is to develop a reliable, easy to use, field kit method for rapid, sensitive, and non-lethal identification of important bacterial pathogens of salmonids, such as bacterial kidney disease in various tissues, including blood, from suspect fish. At present, laboratory extraction of RNA and subsequent identification of bacterial species-specific DNA sequences by a combination of reverse transcription (RT), polymerase chain reaction (PCR) amplification of specific 16S ribosomal RNA, and molecular probing has proven to be a powerful technique. The intent of this subtopic is to further evaluate this concept and develop methods to automate the various steps to make it applicable for reliable field use. Such a field kit will be extremely useful for managers of various types of fish rearing facilities, including those charged with the cultivation and restoration of endangered species.

Reference:

Boddinghaus, B., T. Rogall, T. Flohr, H. Blocker, and E. C. Bottger. 1990. Detection and identification of Mycobacteria by amplification of rRNA. J. Clinical Microbiol, 28: 1751-1759.

8.3.2A SUBTOPIC: Automated Genetic Probe Field Assay for Toxic Algae

The objective is to develop and demonstrate the utility of an automated field test kit for toxic species of marine algae, which will enable the public and private sector to assess the presence of toxic algae in marine waters neighboring commercially and recreationally important shellfish areas. Economic losses due to algal toxins which are accumulated by shellfish include the costs of shellfish monitoring by state health officials; the reduction in sales of commercial fish, shellfish, and crab; the closure of many beaches to the recreational harvest of shellfish during summer months; lost tourist trade; human illness; and sometimes deaths.

Mouse bioassay, the method currently used by Washington State Department of Health for the quantification of toxin levels in commercial shellfish and crustaceans, is a time-consuming laboratory process using live animals. Such use of live animals in the field can be prohibitive and restrictive. Recently, ribosomal DNA has been sequenced and oligonucleotide probes which specifically recognize toxic species of algae have been synthesized (Scholin et. al., 1996; Miller and Scholin, 1996). In theory, the use of these specific DNA probes in conjunction with field processing of seawater will allow real-time estimations of the number and types of toxic algae in a given sample. This on-site "dipstick" test would allow state health officials, native Americans who depend on shellfish for their livelihood, and shellfish fisheries to quickly and efficiently process seawater samples, thereby enabling them to independently quantify toxic marine algal species in areas of commercial and recreational interest.

References:

Scholin, C.A., K.R. Buck, T. Britschgi, G. Cangelosi, and F.P. Chavez. 1996. Identification of Pseudo-nitzschia australis (Bacillariophyceae) using rRNA- targeted probes in whole cell and sandwich hybridization formats. Phycologia 35(3), 190-197.

Miller, P.E. and C.A. Scholin. 1996. Identification of cultured Pseudo-nitzschia (Bacillariophyceae) using species-specific LSU rRNA-targeted fluorescent probes. J. Phycol. 32, 646-655.

8.3.3A SUBTOPIC: Three Dimensional Fish Tracking

The objective is to develop and demonstrate hardware and software for high resolution tracking and determination of position, in three dimensional space, of fish equipped with transponding acoustic tags. Although the quality of range and positioning data will vary with the tag used and with environmental conditions, the maximum reliable range of the system should be at least 150m. One approach to high resolution determination of

range and location of a transponding acoustic tag is triangulation by an array of underwater transducers, using the delay after interrogation of a tag that its signal is returned to the interrogating transducer, and the relative arrival time of the transponded signal at each transducer in the array. Incremental measurements of position will determine the path of a tagged fish in three dimensional space. The intent of this research is to develop a quantitative method to determine the behavior of fish in proximity to structures such as dams and surface collectors as part of an overall attempt to improve the passage survival of fish.

8.4 NOAA TOPIC: OCEAN SCIENCE

8.4.1SG SUBTOPIC: Aquaculture: Water Reuse and Effluent Treatment Systems

Proposals are requested for developing integrated aquaculture systems with minimum impact on the environment. These include development of innovative water reuse systems for ponds and raceways and other novel systems for treating effluent. Special priority will be given to prototype, modular water reuse systems suitable for producing a variety of species anywhere in the United States.

8.4.2SG SUBTOPIC: Aquaculture: Developing and Improving Marine Species Culture

Proposals are requested for research which offers to make significant, industry-wide improvements in marine finfish, shellfish, and marine ornamental fish culture systems for both small scale and large scale applications. Priority will be given to research which finds innovative approaches which will solve major industry bottlenecks in an economically and environmentally compatible manner. Research aimed at new marine species for culture and research to adapt techniques being used successfully in other countries are appropriate.

8.4.3SG SUBTOPIC: Open-Ocean Aquaculture Systems

Both engineering and biological technology needs to be explored for the development of open-ocean or offshore culture systems. Large scale, offshore, submersible, and floating systems need to be developed for Atlantic, Gulf of Mexico, and Pacific conditions. Automation of feeding and harvesting functions as well as telemetry and remote control systems will be considered in this competition. The biological technology

would include hatchery, nursery and transport systems for candidate species for open ocean-aquaculture. Field tests of candidate species are encouraged.

8.4.4SG SUBTOPIC: Value-Added Products for Seafood

The development of value-added products for seafood, including seaweed, is urgently needed to expand the markets of these products. Projects on new processing equipment and techniques, new product forms, international market formats, and the use of underutilized species are appropriate for this topic. Special emphasis will go to products developed from waste streams in established seafood processing activities.

8.4.5SG SUBTOPIC: Sensor Technologies for Measuring & Detecting Microbiota in the Water

Proposals are requested for probes and/or automated sensor technology, for the detection and quantification of specific microbial and environmental water problems, most notably characterization of species-specific identification and detection of human, fish, and shellfish pathogens.

8.4.6SG SUBTOPIC: Alternative Technologies to Ballast WaterExchange

The problem of nonindigenous species invasions is a growing concern in both Great Lakes and marine coastal waters. Many of these invasions occur through release of ballast water, but other than mid ocean ballast water exchange, often a time-consuming and occasionally risky process, there is no effective method of eliminating this pathway for introductions. Research is needed to develop efficient and cost-effective alternative technologies to ballast water exchange for the shipping industry so that mid-ocean exchange of ballast water may be avoided and the risk of introductions reduced.

8.4.7A SUBTOPIC: A Microbial Sampler for Deep-sea Research and Discovery

The microbial diversity at deep-sea hydrothermal vents is poorly studied and yet represents some of the richest potential for basic science as well as for applied biotechnological applications. This lack of knowledge is largely due to limitations in the methodologies for studying microbial diversity but also in part due to the difficulty in obtaining discreet, defined, and reliable microbiological samples. This capability is needed by microbial biologists and biotechnologists interested in sampling deep-sea vents. Some of the features that are required for effective collection of deep-sea microbial biomass, but currently not available, are: (1) a simple sampler that is easily

operated by both submersibles and remotely operated vehicles;(2) that maintains the sample uncontaminated, both during sampling and during retrieval shipboard; (3) that allows multiple sample application, such as core samples, filtered samples; (4) that are pumped, etc.; (5) that takes associated critical physical measurements such as temperature; (6) that allows for microbial activity measurements and/or enrichments to be made *in situ;* (7) that if required, can maintain the sample under pressure (pressures greater than 300 atm) during retrieval; and (8) that can allow for sample transferal under pressure to an isolation chamber.

Such a sampler does not exist, and would greatly enhance our understanding of the microbial ecology of deep-sea vents. Furthermore, with the current heightened interest in the biotechnological application of extremophiles, there is an interest in this community to obtain uncontaminated samples from the deep-sea. Stimulating the development of such a sampler may also attract the attention of sampling devices that need to be developed for uncontaminated sampling on other planets during space missions.

8.4.8A SUBTOPIC: A ROV Mounted Sensor System for Mapping the Distribution of Benthic Microalgae

A sensor system is needed to map the fine scale distribution of microalgae growing on the surface of seafloor sediments. Typically, sediment sampling is required to collect such data; which inherently has lower spatial resolution and is time consuming to process. Initial use of such a sensor would be from an remotely operated vehicle (ROV) platform, but such a system could be mounted to a sled with conducting tow line/wire for wider use in the oceanographic community. We envision an approach which takes advantage of the florescence characteristics of chlorophyll-a, using excitation light filtered through a narrow-band filter. There are several required characteristics for such a system. First is the need for a source of blue light (436 nm). Currently, there are no blue light lasers adequate for this kind of system, so a source which produces a range of light wavelengths around that wavelength and a narrow band filter will be needed. More problematic is the need to sense red (680 nm) florescence coming back at the sensor. Water rapidly attenuates light at 680 nm. Suspended particulates and dissolved organics also affect attenuation and scattering. Self calibration for characteristics of near-bottom water will most likely be needed to determine true emission intensity. Calculations of sensitivity of such a system are needed to assess the validity of data which could be acquired. A feasibility study is needed to determine the capabilities of such a sensor system based on physical constraints, technological limitations, and sensitivity of the sensor.

8.4.9A SUBTOPIC: Improvements to NOAA Airborne Research Radiometers

The NOAA Airborne Water Substance Microwave Radiometer (AWSMR) has proven to be a versatile instrument. In its upward-looking mode, it measures the precipitable water vapor and integrated cloud liquid. In its downward-looking mode, the AWSMR has been used to measure the wind speed and direction near the ocean surface, and to measure oceanic internal waves. Recently, the AWSMR was modified to be capable of scanning a swath of the ocean surface. A new usage for the system is to measure the thickness and extent of surface oil slicks, both natural and accidental. The sensitivity of the current AWSMR is 0.06 K with an accuracy of 0.2 K for a one second integration time. Microwave technology has advanced over recent years making it possible for the AWSMR to be made more compact, to increase the sensitivity of its measurements, and to improve its reliability at all operational altitudes. NOAA is therefore soliciting proposals to convert a ground-based water substance microwave radiometer into a second airborne version utilizing the recent advances in technology. A second task would be to streamline and modernize the current AWSMR.

8.4.10A SUBTOPIC: Polarimetric Infrared Imager

NOAA's Environmental Technology Laboratory is interested in using polarimetric infrared imaging for environmental remote sensing, especially of the ocean surface. Therefore, this subtopic is for development of a polarimetric infrared imaging system operating in a wavelength range of nominally 8–12 μm for use in demanding field environments. Desirable features include small size and weight, capability of maintaining a radiometric calibration to the order of 1%, operation without cryogens, and rugged design. The technology should be capable of characterizing the state of polarization of each pixel in a near-ambient-temperature (~300K) thermal infrared scene from a moving platform, with 1% radiometric and polarimetric accuracy.

8.5 NOAA TOPIC: CARTOGRAPHY AND INFORMATION SYSTEMS

8.5.1A SUBTOPIC: Cartographic Data and Geographic Information Systems (GIS)

Innovations with commercial potential are sought incorporating new and emerging technologies related to digital cartographic and GIS systems to support National Ocean Service (NOS) requirements. The NOS makes its products, data, and metadata available to agencies, academia and the public through electronic access via computer networks. Needed research critical to the NOS mission includes:

- Heads-up raster and vector navigation and nautical charting data shown in 2 and 3 dimensional displays for mariners. Such practical information could be shown on semi-transparent, portable, heads-up displays superimposed in novel ways on the actual environment to help mariners navigate, especially in conditions of limited visibility.

- A comprehensive method for remote real-time monitoring of navigation channel depths to within 1 foot and widths to within 10 feet throughout the entire channel length (1 mile to 100 miles). The method must be comparable in cost to the periodic sonar surveys currently in use. A survey by this method should require 24 hours or less, if possible.

- New methods for generation, update, and transfer of geodata products and data files from spatial data bases, including raster images, to meet emerging requirements of Electronic Chart Display and Information System (ECDIS) and similar shipboard electronic navigation systems using raster displays.

- User-transparent approaches to geodata and geoprocessing interoperability across networks (e.g., the Internet), for:
  - Software Interoperability: Automatically invoked platform independent processing functions,
  - Data Interoperability: User-transparent autonomous standard file format conversions.
- Innovations for easily locating, accessing, searching, transferring, reformatting, and portraying geodata and GIS graphic products across networks. These could involve knowledge processing via expert systems and/or neural nets, hyperlinks (e.g., Netscape-like), geospatial search engines, or improved conventional techniques.

- New methods for enhancing/compressing raster images of nautical chart features, including text and feature symbology. These can range from conventional image processing and optical character recognition algorithms to the use of expert systems, fuzzy logic, neural nets, and specialized pattern recognition/matching algorithms.

- Improved methods for error-free raster-to-vector and vector-to-raster conversion/compression for digital raster images, including semi-automated GIS data attribution and metadata generation directly from the vectorized raster data files.

8.5.2SG SUBTOPIC: Recreational Boat Charting

Recreational boating is a high growth industry and an important component to the economy. Navigational charts are critical to creating safe boating through presentation of traditional piloting and navigation data. However, new techniques make it feasible to include historical and resource management information on charts to give boaters an understanding of the environmental conditions in given areas. Research is needed to (1) Design and test a suitable field methodology utilizing DGPS/GIS/GIS technology; (2) Determine optimal map scale and resolution for recreational boat users; (3) Adapt remote sensing and GIS technologies to photomap product development.

8.5.3A SUBTOPIC: Metadata Creation, Validation, and Management Systems

Proposals related to the development of a Metadata Administrative Tool (MAT) for the creation, validation and management of metadata records in accordance with the Federal Geospatial Data Committee (FGDC) metadata standard. The intent is to create an off the shelf tool to assist the user in dealing with these metadata issues.

The creation of the World Wide Web (WWW), along with Executive Order #12906 have put an extreme burden on Federal agencies in the area of metadata. Agencies are required to create comprehensive metadata records which describe extent, spatial & temporal coverage, quality of record, etc. for each data set they hold. There are currently no adequate software packages available to support this activity, forcing each office or center to create custom code to deal with this complex problem. The result is a mixed bag, with each tool supporting a single aspect of metadata management, achieving varying degrees of success. All of the tools are provided as shareware with minimal documentation, reliability, and support. This often leads to each individual metadata provider creating their own system rather than facing the daunting task of incorporating changes to preexisting programs. What is required is a single tool that can handle all aspects of metadata management and meets the specific requirements below. A review of all known tools is available from http://www.fgdc.gov:80/Metadata/Mitre/task2/index.html .

The tool developed will have broad commercial potential. With the advent of the WWW, the ability to search a distributed archive(s) has been greatly enhanced. Programs such as NOAAServer, MEL, ECSInfo all rely on complete and accurate metadata records while providing no tools to those who are required to create the records. In the non-governmental area, data sellers, such as GIS providers, satellite operators, map makers, etc. could each benefit from such a tool by enhancing their visibility and

accessibility through the WWW. Finally in the retail area the potential is virtually unlimited. By combining customizable data dictionaries with metadata the system would allow an on-line provider to create metadata that is visible globally in multiple languages, thereby reaching into new markets.

Requirements desirable in the developed tool are listed below.

Flexibility in Defining Metadata:
* Provides the ability to create and customize locally defined metadata elements, where the elements may be arbitrarily hierarchical and/or repeating.
* Provides support for standard and custom data dictionaries of controlled vocabulary terms.
* Supports multiple data types for metadata elements (e.g., latitude, floating numbers, memos, dates, etc).
* Specification of elements as optional and with default values.

Ease of Use:
* Provides an easy-to-use graphical user interface.
* Provides data filters for narrowing the selection of data records being viewed to a specified subset based on element criteria.
* Allows user to enter data directly into the system.
* Verifies entered data is in compliance with standards requirements.
* Includes on-line context sensitive help.
* Supports multiple, independent databases of metadata elements.
* Tool must interface to search engines through the Z39.50 specification to permit easy and efficient data interaction with Intranet/Internet.
* Supports metadata imports and exports in standard file formats.
* Supports customizable metadata file import/export for use with user specific metadata.
* Provides programming interfaces for the development for custom imports and exports (e.g., import and exports directly to/from databases).
* Verifies imported metadata prior to inserting data in database (e.g.,the import complies with a standards requirements).
* Supports user configurable mapping between import/export data elements and metadata elements.
* Access clients available from multiple platforms, preferably through a web browser.

Database Connectivity:
* Uses relational database to store and retrieve the metadata via the Open Database Connectivity (ODBC) standard.
* Able to retrieve metadata field updates through the ODBC interface from existing databases.

Standards Compliance:
* Enforces mandatory, optional and mandatory if applicable, aspects of standards (e.g., as specified by FGDC standard).
* Includes predefined, online metadata standard definitions for each core element, including description, usage guidelines, and examples.
* Includes dictionaries of predefined controlled elements as defined by standards.

The subtopics in sections 8.6 through 8.14 are from the National Institute of Standards and Technology (NIST). Approximately 30 awards will be made on these subtopics.

8.6 NIST TOPIC: QUALITY ASSURANCE

8.6.1T/A SUBTOPIC: Quality Management and Health Care

In recent years, health care costs have been 13 percent of the United States Gross Domestic Product and rising. Quality improvement principles are being used increasingly to improve productivity and efficiency of health care delivery and to help contain costs.

The Malcolm Baldrige National Quality Award Health Care Pilot Criteria have the potential to offer assistance to those providing U.S. health care. Proposals are sought on definition of criteria for determination of health care outcomes and adjustments of health care outcomes data to account for case mix and patient risk. The development of algorithms for determining such data and statistical techniques for analysis of the data are sought. Collaborative research with health care institutions is encouraged to provide data for assessment of algorithms.

8.6.2T SUBTOPIC: Quality Management and Education

There is a growing movement to apply quality management principles and the Malcolm Baldrige National Quality Award Education Pilot Criteria to educational systems throughout the United States. Included in this movement are K-12, as well as higher education.

Proposals are sought in the area of outcomes measurements to be used in determining appropriate indicators and improvement trends in educational outcomes. Collaborative research with schools or school districts are of particular interest, since it permits evaluation of research results.

8.6.3T SUBTOPIC: Quality Management Self-Assessment Software

Many businesses and organizations are using Baldrige-based criteria for self-assessment. Self-assessment is frequently used in a strategic planning process by which businesses/organizations deliver greater customer value while improving productivity and asset allocation.

Proposals are sought for a group-ware, LAN-based software package that enables organizations to conduct self-assessments based on the following three sets of criteria: (1) the Malcolm Baldrige National Quality Award Criteria; (2) the Education Pilot Criteria (or Award Criteria); and (3) the Health Care Pilot Criteria (or Award Criteria).

The package shall incorporate the latest version of each of the three sets of criteria for purposes of on-line reference. Users need to be able to record, edit, print, collaborate, compare, and summarize comments and scores for all criteria Categories/Items/Areas to Address. Documentation shall be sufficient to enable novice users to employ the software. Desirable attributes are a fully-integrated graphical interface, a general word-processing capability, and an on-line help system.

8.7 NIST TOPIC: ADVANCED TECHNOLOGY PROGRAM

8.7.1T SUBTOPIC: Technologies for Large Area Electronic Materials and Devices

There is growing technological and commercial interest in active thin film materials, coatings, and membranes for large area electronic applications. These include thin film amorphous silicon, which finds use in flat panel displays and in photovoltaic power modules; solid polymer and ceramic ion conductor membranes, employed in fuel cells and laminated lithium polymer batteries; and electrochromic coatings for smart windows. In all of these applications control of materials properties and structures at the nano or micron level in the solid state is important and results in new electronic functionality over areas larger than a silicon wafer.

To be viable in the commercial marketplace, these thin large area, multilayer devices have to exhibit high performance to size or weight ratio and be capable of being made by processes amenable to cost-effective manufacturing. Proposals are solicited that target the development of new materials, processing, or device structures that can result in significant large area device performance improvements or lead to lower manufacturing cost. Especially encouraged are proposals that are aimed at the development of new rapid, high volume fabrication, or that innovatively adapt processing proven in one industry to large area electronic applications. Emphasis should be directed at large area electronic multilayer devices, especially those that are enabling for power generation and energy storage for wireless, mobile broadband telecommunications. Specifically excluded are proposals in the microelectronics area.

8.7.2T SUBTOPIC: Learning Technologies

Learning technologies relate to an interest in technical solutions which enhance the delivery of information to learners and educators, as well as directly enabling learner-centered activities. Although the requirements of learners and educators vary from one setting to another, certain processes fundamental to learning and pedagogy can be

greatly enhanced by information technology. These include, but are not limited to: a) knowledge representation -- making educational tools which are usable and comprehensible; (b) knowledge management -- facilitating the acquisition, organization, and dissemination of information; (c) interaction facilitation -- making objects in an on-line learning context manipulable and supporting sense-making activities; and (d) learning contextualization -- maintaining learning contexts and enabling a set of information to become a common object of consideration within a learning community.

Technical challenges associated with supporting these processes and for which proposals will be accepted are:

1. Content production and management software. Here the main technical challenges relate to the following fields: (a) search algorithms; (b) multimedia and cross-media indexing tools; and (c) learner-centered and learner-paced navigators. Probabalistic graphical models would be included here as applicable to database mining and navigation.

2. Visualization software as applicable to the user interface. Here the main technical challenges appear to fall within the following areas: (a) 3D optimized displays, (b) visual user preference filters, and (c) interactive visualization software.

3. Distributed simulation as applicable to networked open systems. Here the main technical challenges appear to fall within the following areas: (a) network simulation; (b) artificial intelligence monitoring software; and (c) collective and iterative user support technologies (i.e., authoring tools).

4. Systems management. Here the main challenges fall into three areas: (a) usability testing and design, (b) pricing and delivery, and (c) capacity management.

It is believed that the successful development of technical solutions in any of these domains will depend on the clarity of pedagogical objectives and a depth of understanding of the institutional context within which the envisioned learning technologies will be deployed.

8.7.3T SUBTOPIC: Emerging Thin Materials and Devices

Novel thin film materials, coatings, and membranes are used in a unique multilayer structure where control of materials properties, structures, and phases on a nano or micron level is important; surface and interface molecular engineering is paramount; novel morphologies are often employed, such as amorphous or nanocrystaline phases;

new functionality is achieved in the solid state over large areas; and high performance is required that pushes optoelectronic or mechanical strength limits.

Thin film, coatings type processing is employed, which makes possible large area coverage; low cost; high volume, rapid throughput; and automated, continuous manufacture.

Novel device or parts structures are possible in which integrated architectures can be employed; monolithic arrays of many devices can be possible with relatively small feature sizes; large areas are covered but with low materials usage; high performance to size or weight ratio is possible; properties of the underlying substrate is enhanced; and multidimensional combinations of many thin film materials are employed. Emphasis is placed on achieving new functionality in applications as diverse as smart electrochromic windows and thin film batteries; high resolution displays using new carbon field emitters; large area, thin film amorphous silicon semiconductors for digital X-ray imaging; and superhard diamond and amorphous carbon coatings for cutting tool and tribological applications; multilayer, ion conducting, electronic ceramic membranes for oxygen and power generation; and rapid thermal processing which enables large area semiconductor processing important to photovoltaic and semiconductor devices.

8.8 NIST TOPIC: ELECTRONICS AND ELECTRICAL ENGINEERING

8.8.1T/A SUBTOPIC: Characterization Techniques for Silicon on Insulator Material

Silicon on Insulator (SOI) is an emerging technology of choice for use in production of silicon integrated circuits. Two approaches have been developed for producing the material: ion implantation of oxygen and bonding and etching of silicon wafers. Both approaches have succeeded in reducing the levels of microscopic defects in the silicon and oxide films to low, but detectable, levels. Extremely sensitive characterization techniques have been developed to achieve this result. As the defect level of the material is reduced, and the production level of wafers increased, present characterization requires improvement. In general, the measurement challenge is to ensure very low levels of microscopic defects in heavily processed thin film structures.

NIST is seeking proposals to develop characterization tools to address the specific problems of SOI technology. Possible topics include: (1) higher sensitivity techniques for microscopic detection of defects, (2) nondestructive techniques for characterization of large area (200 mm) SOI wafers, (3) new techniques for detection of new defect

types, (4) quality control characterization methods suitable for use during the SOI wafer fabrication process, and (5) automation of characterization for volume production of SOI.

The Phase 1 contract will be a proof-of-principal demonstration. Proposals should include procurement or production of sufficient suitable material (SOI wafers) for development and demonstration.

8.8.2T SUBTOPIC: Data Exchange Tools for Electronics Assembly

Process control files provide the instruction sets used by electronic assembly equipment to accomplish specific tasks. The lack of a standard for the construction of process control files has resulted in a proliferation of proprietary, vendor specific systems, which has proven to be a burden to their customers. It is believed that significant cost savings and greater flexibility could be realized by software developers, equipment suppliers, and electronics manufactures through a standardized method to represent product and process data in process control files. Such a standard is being developed (the Standard Recipe File Format) that addresses this technological gap.

Once the SRFF standard has been established (a stable version is expected in 1997), the need for certain low-cost generic software tools would arise almost immediately in the electronics manufacturing industry. Companies will either develop SRFF-compliant tools internally, or purchase them. Since tools outlined in this effort would be pre-competitive in nature, developing these tools internally would not be a revenue generator for most companies—but a cost. Consequently, establishing a market source for these tools would therefore save companies valuable resources, both in terms of tool development and equipment support. The development would be conducted once, versus dozens or hundreds of times.

NIST is soliciting proposals for an initial set of SRFF-compliant tools. The contractor would work in collaboration with the Surface Mount Equipment Manufacturers Association's SRFF development effort to both define, prototype, and finally make commercial-ready a suite of SRFF-compliant tools. Such a tool suite would be expected to include: a SRFF parser; tools to load SRFF files into a database, and then manipulate and visualize the data; and tools to handle user-extensions to SRFF files. Once available, these tools would be used by NIST researchers to demonstrate electronic commerce of electronics assembly services, and would complement the work NIST is doing with the National Electronics Manufacturing Initiative. More importantly these tools would have a positive impact on the U.S. Electronics manufacturing industry: this impact could easily be measured through the number of tools sold by the winner of this SBIR.

8.8.3T SUBTOPIC: Virtual Electronic Component Toolbox for ECCI

Electronic Commerce of Component Information (ECCI) requires the ability to locate, organize, and access component information such as, simulation models, physical dimensions, thermal data, timing models, synthesis scripts, and other types of engineering data. This is becoming an increasingly complex task. The current ability to "publish" such information electronically is making this task more challenging, due to the need to "link" or wrap these diverse sources of information so that a design engineer can make effective use of them. Tools are needed to help electronics designers and manufacturers locate, organize, access, and edit the information and data for electronic components. A designer may know that they need an electronic component which satisfies a set of performance and functional parameters. There are currently no tools available to help locate, organize, edit, and access such information via the WWW so that it can be efficiently incorporated into a design and manufacturing lifecycle.

NIST is soliciting proposals for the development of a such a tool or suite of tools, to be designed in a phased approach with the initial implementation being a Java applet (for platform independence), which can display and edit component information as defined by the ECIX Pinnacles Component Information Standard (PCIS) format, including links to online dictionaries, such as the NIST developed dictionary framework. This tool would be very extensible and would allow the engineer to dynamically add links to any additional component information which may exist both internally and externally to his company. The long term goal is to develop a tool that could be made commercially available at a very affordable price, to allow designers and manufacturers to organize and access component information within an electronic commerce infrastructure. This could also be thought of as an electronic toolbox where engineers can collect a wide variety of electronic information about all the components they use in their designs.

Future phases of this proposal would add the ability to browse, link, edit, maintain, and publish other standard formats as they emerge within the industry. Future development would also allow manufacturers to easily publish and maintain their electronic databooks via a Java applet capable of reading and writing standard formats, such as Pinnacles ECIX, and other emerging standards including Virtual Socket Interface Alliance (VSIA) developed standards. Version control, preferred parts lists, and intelligent BOMs (Bill of Materials) would also be part of this future work. Another important aspect of future work will be the inclusion of intelligent agents customized to

search for new engineering data as it comes on-line, and to link that data into the existing collection of data.

8.8.4T SUBTOPIC: IT Metrics for Electronics Manufacturers

While automation technology promises and often delivers tremendous benefit to manufacturers, automation choices are often made without the benefit of reliable business metrics. Managers require effective metrics to allow them to make effective comparisons among factory information system options, such as the selection of Enterprise Resource Planning or Manufacturing Execution System software systems, or deciding to upgrade legacy systems in-house. One role of business metrics would be to demonstrate that the promised value is indeed delivered. This proof is complicated by the fact that there will also be other active projects that impact the same metrics, such as product design improvements to improve yield, which would need to be accounted for. Another objective for business metrics would be the ability to project the cost of NOT performing an installation or upgrade. This should include an assessment of the costs incurred in sneaker-net, data reentry, data duplications, and other costs associated with un-integrated implementations in place.

NIST is soliciting proposals to develop a set of business metrics that correlate technical metrics (such as MIPS, FLOPS, and data rates) with business metrics (such as factory effectiveness and time-to-yield) to aid manufacturing management in their efforts to build an optimum information infrastructure for deployment by electronics manufacturers. The contractor will work closely with the Factory Information Systems (FIS) Technical Implementation Group (TIG) of the National Electronics Manufacturing Initiative (NEMI) to develop such a set of metrics for electronics manufacturers. The project will result in a list of metrics that can be selected for use in evaluating FIS cost/benefit/risk in an electronic manufacturing environment. The metrics will be supplied as part of a report detailing each metric, its derivation from a common business metric, and how it is related to a FIS metric. The final deliverable is a procedure for applying and interpreting the metrics. This may be in the form of a spreadsheet or other automated software tool. The tool should support decisions ranging from NOT implementing any changes, to various levels of upgrades, to a fully integrated FIS integrating the full functions of the company. Verification against existing installations will be required to validate the accuracy of the metrics.

Schedule:

Phase 1 should include the following tasks: (1) survey metrics used in other (manufacturing and non-manufacturing) industries; (2) draft selected business metrics; (3) draft list of FIS metrics; (4) draft algorithm for correlation between business and technical FIS metrics; (5) final reports of above.

Phase 2 should include the following tasks: (1) a commercial-ready decision-support tool which implements the metrics, and is geared towards the electronics industry; (2) verification benchmark demonstration at one or more electronics manufacturing sites; (3) draft report of application of benchmark and verification against expected outcome; and (4) final reports and procedures.

8.8.5T SUBTOPIC: Scanning Probe AC Impedance Microscope

Dopant profiling of silicon in two-dimensions (2-D) with 10 nm spatial resolution and 10% accuracy over the dopant range of 10^{20} to 10^{17} cm^{-3} is a critical measurement need for next-generation integrated circuits. Two scanning probe microscope (SPM) methods have been developed to measure 2-D dopant profiles: nano-spreading resistance and the scanning capacitance microscope (SCM). Both techniques measure some aspect of the probe tip to semiconductor electrical impedance. Nano-spreading resistance measures dc resistance, while SCM measures capacitance with a resonant peak shift sensor at 915 MHZ. The impedance of the SPM tip to a semiconductor has not been extensively investigated at intermediate frequencies.

NIST is seeking proposals to develop instruments which will integrate analysis of the tip-to-semiconductor impedance from *dc to the low GHz* range with a scanning probe microscope. Desirable tools would be sensitive to variations in semiconductor dopant concentration, lifetime, surface states, dielectric constant, and/or buried layers of a multi-layer integrated circuit structure. Possible implementations of the tool may be an ac version of nano-spreading resistance with relaxed tip/sample constraints, or an ac impedance microscope capable of simultaneously measuring both the resistive and capacitive (real and imaginary) components of tip-to-sample impedance.

The Phase 1 contract will require an investigation of the tip-to-sample impedance over the frequency range of interest, techniques to apply high frequency signals to a semiconductor with a nano-probe tip (such as micro-strip lines), and identification of optimum frequency range and measurements for imaging the various properties of a semiconductor.

8.8.6T SUBTOPIC: Agile Wavelength Tuning for Diode Lasers

NIST has developed probes which use optical-fiber links and electro-optic transducers to measure rf and microwave electromagnetic fields. Such probes require a means for stabilizing their output against other environmental changes, such as temperature

changes and acoustic vibrations. One way to accomplish this could be by rapidly tuning the wavelength of the diode source laser over a 1 to 2 nm wavelength range in a few microseconds. Presently available tunable diode laser systems are unable to meet this demand.

NIST is soliciting proposals to develop diode lasers and/or tuning systems that will meet this requirement. A couple of possible technologies for realizing an appropriate tuning system might be electro-optics or surface acoustic waves, but any technology which meets the requirements would be considered. The system should simultaneously produce a narrow spectral line with a width of less than 10 MHZ and the capability of eventually getting below 1 MHz. Since such a tuning system would have applications in many other optical fiber based sensor systems, there would be a substantial commercial market. In addition, with only slight improvements, it could be used in wavelength multiplexed telecommunication systems, where a very large commercial market is expected to develop in the near future.

Reference:

Masterson, K.D., D.R. Novotny, and K.H. Cavcey. 1996. Standard antennas designed with electro-optic modulators and optical fiber linkage. Intense Microwave Pulses, IV, H. Brandt. ed. SPIE 2831, pp. 188-196.

8.8.7T SUBTOPIC: Electrooptic Modulator Wavelength Controlled Bias Point

NIST has developed probes which use optical-fiber links and electro-optic modulators to measure rf and microwave electromagnetic fields. Environmental effects such as temperature changes and acoustic vibrations cause changes in the modulator's optical bias points that affect system performance. As an alternative to trying to achieve complete stability in the modulator against such effects, NIST has pursued an approach whereby using an appropriate modulator design, such changes can be compensated by servo controlling the laser wavelength, thus achieving stability in the full system response.

NIST is soliciting proposals to develop electro-optic modulators specifically designed to meet this requirement. Techniques explored to date have utilized resonant cavities or unbalanced, two-beam modulators, and require additional discrete components, such as polarization spliters and Faraday rotators for proper operation. We would be interested in modulator designs that eliminate the need for such extra components, or which integrate them into a single structure. They should have complementary outputs to provide common mode noise rejection, and to use for feedback control of the laser

wavelength. Frequency response of at least 3 GHz is required, but a capability for extending it to above 20 GHz is also desirable.

Reference:

Masterson, K.D., D.R. Novotny, and K.H. Cavcey. 1996. Standard antennas designed with electro-optic modulators and optical fiber linkage. Intense Microwave Pulses, IV, H. Brandt. ed. SPIE 2831, pp. 188-196.

8.8.8T SUBTOPIC: 4-port On-wafer Calibration Software and Standards

This program will develop and commercialize calibration software, standards, measurement methods, and instrumentation for the on-wafer electrical characterization of microwave 4-ports. The aim of the system will be to reproduce, in a commercial environment, accurate multiport and multiconductor calibrations and measurements developed and under development at NIST. Both passive and electronic calibration standards may be considered. New test instrumentation may be developed or existing test instrumentation may be employed to meet these goals. The system should be designed for the accurate measurement of 4-port microwave components of the type being developed for wireless communications systems, and for package and interconnect characterization. The system design should allow eventual extension of the measurement technology to millimeter wave frequencies.

8.8.9T SUBTOPIC: *In Situ* Composition Measurements of Quaternary Semiconductors

A number of important optoelectronic devices are based on quaternary semiconductor alloy systems, for example, AlGaInP for visible lasers and InGaAsP for infrared optical fiber communication devices. The composition of the epitaxial layers in these devices is calibrated with separate growth runs and ex situ measurements, so that the current manufacturing process requires time and materials resources directed away from actual device runs, and cannot correct for run-to-run variations in real time. While optical techniques may be used to determine material band gap at growth temperature, this information is insufficient to determine a composition value for quaternaries, and deposited films can, therefore, reach an unacceptable level of strain before a problem is identified. We require a new technique or combination of techniques, including but not limited to, real time flux measurements and in situ optical spectroscopy, to determine compositions of quaternary III-V semiconductors during growth. Instruments should be designed or tested so as to identify and respond to the major causes of run-to-run variation in molecular beam epitaxy (MBE) and/or organometallic vapor

phase epitaxy (OMVPE) growth systems. This information may be used to reduce the cost of real-time measurement when one or more of the source material delivery subsystems are sufficiently reproducible to make flux monitoring unnecessary. Preference will be given to proposals in which Phase 2 work will include publication of measurement results and delivery of a prototype measurement system to NIST.

8.8.10T SUBTOPIC: *In situ* Resistivity Measurements during Epitaxial Growth of Semiconductors

Although a number of properties of epitaxial semiconductor films can be measured in situ, resistivity or doping level is still determined by post-growth characterization. The use of ex situ characterization mandates expensive calibration runs, limits flexibility in changing device design parameters, and generally requires destructive testing for samples with more than one layer. We are requesting proposals to demonstrate techniques for the measurement of carrier concentrations in the range of 1016 to 1019 cm-3 in semiconductor films as they are being grown. The techniques should be compatible with use in molecular beam epitaxy (MBE) and/or organometallic vapor phase epitaxy (OMVPE). In keeping with industrial needs for device manufacture, at least 20% accuracy and 10% precision should be achievable in principle. Phase 1 research should provide a proof-of-concept for the measurement technique and data analysis. Phase 2 work is expected to include demonstration of the measurement technique during growth of films, with different doping levels covering the above range.

8.8.11T SUBTOPIC: Cold On-Wafer Noise Source

Suitable artifacts are needed for use in interlaboratory comparisons of on-wafer noise-temperature measurements, and for use as industry check standards. Measurement of noise temperature is fundamental to general noise-parameter measurements. NIST is developing methods for the accurate on-wafer measurement of thermal noise to support measurements of noise parameters of integrated circuit devices, such as low-noise transistors. NIST has recently developed and verified the capability to accurately measure noise temperature on wafer, and is developing on-wafer noise sources with high noise temperatures (~10,000 K, ENR ~15 dB). There is now a need for a source with a low noise temperature, which is more sensitive to common error sources, such as ambient contributions to noise power.

The frequency range of interest is 1 GHz to 18 GHz, particularly the 8-12 GHz and 1-2 GHz bands, with a source noise temperature less than 150 K, and constant to within about 2 K over any 10 MHz frequency band. The source is intended for circulation in

inter-laboratory comparisons, and must be mechanically and electronically robust, with an output stable and repeatable to within 0.5%. The output lines should coincide with those of the NIST on-wafer CPW calibration set, and the reflection coefficient should be less than about 0.3. Electrical power or bias requirements must be satisfied by readily available power, voltage, or current supplies, and transferred to wafer by common CPW probes. Any additional required circuitry must be provided with the source. One possible source could be the reverse radiation from a FET. Approaches employing cold physical temperatures are discouraged, unless the need for cumbersome cooling equipment can be circumvented. A variable output noise temperature, although not required, is considered a desirable bonus, but only if source stability and repeatability are not degraded.

Such a cold noise source will have commercial applications beyond its intended use. It could be packaged as an internal reference source for systems measuring noise parameters, with accuracy improvements over systems using high-temperature sources. It could also be used to calibrate non-laboratory low noise temperature radiometers, as used in space applications.

References:

Randa, J. 1997. Noise temperature measurements on wafer. NIST Tech. Note 1390.

Williams, D., R. Marks, K. Phillips, and T. Miers. 1991. Progress toward MMIC on-wafer standards. *36th ARFTG Conference Digest*; Monterey, CA; 73-83.

Frater, R.H. and D.R. Williams. 1981. An active 'cold' noise source. IEEE Trans. Microwave Theory & Tech., MTT-29(4), 344-347.

Dunleavy, L.P. *et al.* 1997. Design and characterization of FET based cold/hot noise sources. *1997 IEEE MTT-S International Microwave Symposium Digest*, 1293-1296, Denver.

8.8.12T SUBTOPIC: Intrinsically Shunted Josephson Junctions for Programmable Voltage Standards

Superconductor-normal-superconductor (SNS) Josephson junctions are required for programmable voltage standard systems. SNS junctions can provide large critical currents (> 1mA) and I_cR_N products in the 10-100 microvolt range while maintaining nonhysteretic current-voltage characteristics. Significant advances have been made in low temperature superconductor (LTS) SNS junction technology using PdAu normal metal junction barriers. However, PdAu SNS junctions with 30 μV I_cR_N products have

critical current densities greater than 200,000 A/cm^2. This large current density is not ideal, because it requires junction diameters less than 2 μm. Since large currents are required to bias these very small junctions, the maximum ac or dc bias current that can be passed through wiring contacts and crossovers sometimes limits design performance.

NIST is soliciting proposals for the fabrication of LTS SNS trilayers with novel normal-metal barriers that provide resistivity greater than 50 $\mu\Omega$ cm. The superconducting material should be niobium. Junction barrier thicknesses should be adjusted in order to achieve current densities less than 100,000 A/cm^2 while maintaining I_cR_N products greater than 30 microvolts. Junction uniformity should be demonstrated by fabricating arrays of at least 1000 junctions. Arrays should be embedded in appropriate microwave circuits that ensure uniform microwave power coupling, so that power and junction uniformity can be characterized at the characteristic frequency of the junctions. Chip size and layout should be compatible with present NIST test probes for characterization at NIST.

8.8.13T SUBTOPIC: High Temperature Superconducting Programmable Voltage Standard

Josephson voltage standards working at 4^o K produce the ultimate in accuracy for dc voltage measurements at 10 V, and have recently been extended to rapidly programmable voltages up to 1 V. The requirement for operation at liquid He temperatures will limit the range of applications even for the more versatile programmable voltage standard. There have been significant recent improvements in the fabrication of high temperature superconducting (HTS) Josephson junctions. The possibility has arisen for a low-voltage high-speed measurement system using a HTS programmable array operating at temperatures between 30 K and 77^o K. NIST is soliciting proposals for the fabrication of a HTS Josephson junction array configured for binary programmable operation. The junction array and integrated microwave circuit should operate well above 30^o K using a junction technology capable of 1-s spreads less than +/- 10%. We require binary sequences of junctions with I_cR_N products of approximately 20-50 μV (and critical currents of at least 500 μA) at the operating temperature. Subarrays of at least 128 junctions are desirable for spread tests. The appropriate integrated microwave circuits will include coplanar waveguide transitions, termination resistors, and filters on the dc lines. Chip size and layout should be compatible with the present NIST test system.

8.9 NIST TOPIC: MANUFACTURING ENGINEERING

8.9.1T/A/CC SUBTOPIC: Computational Tools to Support Design Artifact Knowledge Repositories

Engineering design involves a mapping between one or more specified functions and a (description of a) realizable physical structure -- the design artifact. The design process involves both top-down decomposition and bottom-up problem solving. The development of computational tools to aid in the design process requires a rich object-based representation scheme that integrates knowledge-based reasoning, constraint processing, geometric modeling, and easy access to large component data/knowledge-bases. While the representation of geometric information has been the subject of extensive efforts, representations for other types of knowledge that are an essential part of the design process (such as function, behavior, and design rationale) are less mature and lack accepted standards. While the ultimate goal is to develop a general "intelligent computer-aided design tool," the scope of this proposal topic is limited to the development of a suitable scheme for both representation and access (index and retrieval) to part and assembly information, including design process models, multi-media data, and appropriate links to commercial CAD tools. An additional requirement is that the tool should be compatible with all platforms commonly used by small to medium enterprises, or should be easily accessible from such platforms (e.g., via the Internet).

NOTE: It is expected that a Phase 2 effort will result in the construction of prototypes.

8.9.2T/A SUBTOPIC: Software Components Specification and Performance Database

It is anticipated that a commerce in third-party software components will continue to emerge and flourish. Several key technologies and support structures must be developed in order to make this happen. One key hurdle is to allow potential users of software components to efficiently evaluate competing software components, based on the user's system design requirements. In the area of research algorithms for intelligent systems, a user has only a research paper or commented source code available to evaluate whether the software component will meet the system design requirements. At NIST, we have proposed a template of formalizable specifications that, when instantiated for a particular component, will completely define that component. (See http://isd.cme.nist.gov/proj/ sw_component_spec/formal.html to download a copy of a paper describing this work in more detail.) These specifications

can be employed by the user to efficiently and securely evaluate whether the component meets the system requirements.

We would like to see technologies and support structures to allow these specifications to be used to solve real applications of intelligent system software developers in U.S. companies. In particular, we would like to see a computer server be put in place that would be a repository for intelligent system software components specified according to the NIST model described above. A Phase 1 effort would be to design the database and its requirements. This would include: (1) design the database to allow the component developer to keep aspects of the component proprietary, while still allowing the user a variety of options to examine the nature and performance of the component; (2) design a user interface that will be required to enter components into the database easily and efficiently, in order to effectively entice developers to place their components in the database; and (3) design a user interface that will allow the user to effectively examine and even do early system simulations using the component specifications. A Phase 2 effort would be to create the server with its database, populate it with appropriate intelligent systems algorithms (components), and install it at NIST. An important requirement is that the awardees would need to perform this research in concert with researchers in the NIST Intelligent Systems Division (ISD).

8.9.3T/CC SUBTOPIC: Green Engineering Concepts for Next Generation Vehicles

Increasingly stringent environmental regulations are putting more and more pressure on the automotive industry to develop new concepts for component designs. As an example, at the turn of the century, most refrigeration systems were carbon dioxide-based. They were eventually replaced by more compact freon based systems. Because carbon dioxide costs 1/100th the cost of a non-ozone- depleting freon, and does not require the use of costly freon machinery, there is renewed interest in the use of carbon dioxide as a refrigerant for automobile air conditioning systems. This and other examples of environment-driven design concepts, are pushing researchers and developers to make these concepts realizable, practical, and affordable. The issue common to all these cases is the engineering design. Proposals are solicited that will utilize advanced CAD tools (such as network-centric CAD, and novel design exploratory tools) for the development of designs that will not only be simple, but easy to manufacture, taking into consideration multiple lifecycle aspects of the product.

NOTE: It is expected that a Phase 2 effort will result in the construction of prototypes.

8.9.4T SUBTOPIC: Telemetry System for Machining Applications

The purpose of this request is to develop a telemetry system, such that the basic data and new theoretical models required to optimize and increase productivity in high-speed milling can be optimized. The focus of the NIST research is on developing means for increasing tool vibrational stability, and on eliminating the need for empirical determination of process stability on a case by case basis. Vibrational stability is one of the major factors limiting material removal rates in high-speed milling. This is especially true in cases where significant tool flexibility is unavoidable, such as in the milling of deep channels or pockets with small corner radii. Consequently, a great deal of research has been devoted to both predicting the critical parameter values for the onset of vibrations (chatter), and to increasing the stability of the process.

In order to control tool vibrations in milling, improved measurement techniques are necessary. Specifically, a method must be devised to measure the deflections of rotating tools during machining, and preferably these deflections should be measured in the rotating frame of reference. One means of doing this is to take advantage of strain measurement techniques, such as those developed for measuring vibrations in turbines. These measurement systems make use of FM telemetry and inductively coupled power coils to operate and extract data from low mass strain gage-bridge-amplifier circuits mounted on the rotating equipment. In this effort, we are asking for the development of a telemetry system to measure dynamic strains in high length-to-diameter ratio tools during milling, such that NIST can use this information to devise new means of stabilizing tool vibrations and thereby increasing material removal rates. The proposed system will measure two bending strain signals with a bandwidth of 50 kHz per channel, with a measurement error of less than 1%. The system must operate at rotational speeds of up to 20,000 rpm, and fit in a tool holder on a high-speed milling machine. Detailed drawings of the tool holder are available from NIST. NIST also requires that in the future, similar systems be adapted to utilize other sensors, such as tool-mounted thermocouples.

8.9.5T SUBTOPIC: Virtual Manufacturing Metrology

Economically competitive manufacturing requires the efficient use of computer-controlled machine tools and coordinate measuring machines. Effective use of these capital resources involves selection of the machine best able to complete the job, i.e. neither over allocation nor under allocation of manufacturing resources. A principal determinant of quality in the manufacturing of discrete-part products is the ability to manufacture and verify the conformity of machined part features. One concept to accomplish this is the use of virtual manufacturing metrology, which is a computer simulation-based mathematical model of the capability and error sources of the machines. Typically this may involve many hundreds of simulations of the

manufacturing scenario; each simulation differing by the particular configuration of errors and uncertainties assumed to be present in the system. The resulting collection of simulations can be used to assess the conformity of the final result. This will be consistent with current ISO guidelines for the expression of measurement uncertainty.

The simulation should be capable of modeling real industrial conditions, including (but not limited to) environmental factors, operator effects, and the myriad of errors present in manufacturing and measuring equipment. The simulation should be based on data that is practically and economically obtainable in an actual factory environment, and the simulation integration between the machine tool and measuring machine should be seamless. The system should be capable of operating on standard Win 95/NT type computer platforms.

8.9.6T SUBTOPIC: Internet-based Manufacturing

U.S. manufacturers face unprecedented challenges and opportunities in the operation of information-based enterprises. The manufacturing industry is increasingly operating on a model of production in which Original Equipment Manufacturer's (OEM's) assemble products out of components produced by a network of widely distributed suppliers. This model is emerging into one in which manufacturing operations are treated as distributed services accessible via the Internet. The use of the Internet by OEMs to locate, contract, link, and even execute manufacturing services offers improvements in cost, cycle-time, and quality. The current opportunity is afforded by advances in several areas: (1) industry and government researchers are defining the Next Generation Internet to enable secure, dedicated bandwidth to its users, (2) electronic commerce protocols are emerging rapidly and through increasing use are becoming more effective, (3) standards are emerging for distributed object-oriented software systems that describe interfaces to manufacturing objects, and (4) Manufacturing Execution Systems (MES) are emerging that enable flexible control over manufacturing operations.

We solicit proposals to develop tools and protocols which address part or all of the following:

- Define manufacturing operations as network-based services.
- Link distributed manufacturing execution system frameworks into an extended manufacturing enterprise.
- Schedule and execute operations across a framework of distributed Manufacturing Execution Systems.

- Combine Electronic Commerce protocols with distributed object protocols to publish, subscribe, and contract for manufacturing services.
- Formalize information needed to interface distributed manufacturing services.
- Combine precise descriptions of manufacturing processes and operations with enabling protocols and methodologies to enable global distributed commercial operations.
- Apply advances in distributed object technology, advanced process control and simulation to establish a new network-based manufacturing paradigm.
- Provide proof-of-concept demonstrations to reduce risk of adopting the paradigm of distributed, Internet-based manufacturing services.
- Provide metrics for intercomparison and adoption of technologies enabling Internet-based manufacturing services.

It is recommended that proposed efforts leverage existing work in the research community on electronic commerce, distributed object systems, Manufacturing Execution Systems, and enterprise integration. Web sites for material referenced above include: (1) NIST Manufacturing Engineering Laboratory, Manufacturing Systems Integration Division: www.nist.gov/msid, (2) CommerceNet: www.commerce.net, (3) Object Management Group: www.omg.org, (4) National Industrial Information Infrastructure Protocols: www.niiip.org. (5) SEMATECH CIM Application Framework: www.sematech.org/public/cim-framework/home.htm.

8.9.7T SUBTOPIC: Next Generation Process Exchange Tools and Applications

As manufacturing companies move toward increased integration, there is a growing need to share process information in addition to product data. Software applications range from those that simply portray processes graphically to tools that enable simulation, planning, analysis, scheduling, and/or control of processes. In collaboration with industry and academia, NIST is developing a Process Specification Language (PSL) that will be common to all manufacturing applications, generic enough to be decoupled from any given application, and robust enough to be able to represent the necessary process information for any given application. Additionally, the PSL will be sufficiently well-defined to enable exchange of process information among established applications.

NIST is requesting proposals for computer-based tools to facilitate the use of the PSL for process modeling and process information exchange. Proposals should target the specification and design of generic PSL-based development and integration tools or extensions to manufacturing application software. Solutions could involve the

development of translators or wrappers for exchange, or tools for creating and editing PSL presentations.

References:

http://www.nist.gov/psl/

Schlenoff, C., A. Knutilla, S. Ray. 1996. Unified Process Specification Language: Requirements for Modeling Process. NISTIR 5910, National Institute of Standards and Technology, Gaithersburg, MD.

8.9.8T SUBTOPIC: Analyzing Manufacturing System Performance through Architectural Formalization

The NIST Intelligent System Division has been developing the Intelligent System Architecture for Manufacturing (ISAM), which forms the basis for manufacturing systems, such as the Next Generation Inspection System Workstation and the Hexapod of the NAMT. NIST plans to further develop and apply ISAM to many other complex manufacturing systems. Being able to analyze system performance, completeness, and consistency of systems designs would greatly enhance a user's ability to develop and deploy ISAM based systems.

The first step in achieving this goal is to use a formal language, such as Z, an architectural description language, such as Rapide, or a robust software engineering paradigm, such as an Object Oriented method, to describe ISAM. Once described, compiler-like tools can be generated to check the architecture for completeness, compliance, and consistency. Problems such as a particular data requirement not being accounted for can hopefully be detected.

A second step is to develop a toolset that can "execute" the formally described system to examine the correctness of a system's performance. Issues such as whether a goal state is reachable and the degree of redundancy that exists in the system can be examined.

A third step is to develop a compiler to convert the formally described system design to conventional computer code, such as C++.

NIST is soliciting proposals that either develop a formal language/software engineering paradigm or apply an existing set to describe ISAM. The deliverable for the Phase 1 should include a description of ISAM within the language/software engineering paradigm, and the first version design of the aforementioned toolset and compiler.

8.9.9T SUBTOPIC: Ontological Engineering Applied to Manufacturing System Integration Research

The Manufacturing Engineering Laboratory is soliciting proposals for the application of the principles behind ontological engineering towards the area of manufacturing systems integration and/or research. The result of this effort will either be: (1) mechanisms, infrastructures, and/or methodology tools with an ontological underpinning that will facilitate the interoperability of manufacturing systems; or (2) the application of ontological principles towards the creation of an electronic notebook, as described below. Within the former area, these principles may be applied to information that is to be shared among manufacturing applications, including, but not limited to, process, resource, product, and design information. Special emphasis will be given to proposals that are applicable to multiple types of information.

The implementation of an ontology-based electronic notebook system (option 2), should allow researchers to collaborate, build, and review domain-specific ontologies and knowledge bases. The implemented system should demonstrate its applicability to a collaborative engineering or manufacturing setting. Each ontology and associated knowledge base(s) [the data] is inherently domain-specific. However the electronic notebook system itself should be domain independent. The system must be based on knowledge representation and interchange formats which permit interaction and possible integration with other such knowledge systems, e.g. KQML and KIF. The use of agent technology is recommended to coordinate and integrate cooperating researchers' electronic notebook entries, and to facilitate integration with other knowledge systems. The user interface(s) should be platform-independent, and other system components should be platform portable. It is expected that a proposed system should leverage prior work in the field of electronic notebooks.

In the context of this proposal, an ontology is an explicit treatment of some topic. It is a formal and declarative representation which includes the vocabulary (or names) for the terms in that subject area and the logical statements that describe what the terms mean and how they can or cannot be related to each other. Ontologies, therefore, provide a formal means for representing and communicating knowledge about some topic and a set of relationships that hold among the terms. Without these formal and concise definitions of attributes, relations, and concepts, usually built upon some type of foundational theory, integration of manufacturing applications runs the risk of misinterpretation of those concepts, leading to problems with interoperability and exchange.

References:

Toronto Virtual Enterprise Project
(http://www.ie.utoronto.ca/EIL/tove/ontoTOC.html)

Knowledge Sharing Effort
(http://www.cs.umbc.edu/kse/)

The Ontolingua Server Project
(http://ksi.cpsc.ucalgary.ca/KAW/KAW96/farquhar/farquhar.html)

Plan Ontology Project
(http://www.aiai.ed.ac.uk/~bat/ontology.html)

Process Interchange Format
(http://soa.cba.hawaii.edu/pif/)

8.9.10T SUBTOPIC: Component-based Software for Agile Process Planning

Current process planning software systems are in a closed form with rigid structures. They are not only monolithic but also too generic and too complicated. Process planners find it difficult to customize these systems at the time of process planning to suit their specific and dynamic needs. These needs include, for instance, adding customized functions, changing the sequence of planning activities, integrating with related systems, and extracting needed data. A new form of process planning software is needed to allow users to rapidly develop customized software. This form of software is component-based process planning software. A software component is a functional unit, with specified algorithms, that has an open interface to communicate with users and other components. Component-based software should consist of a software library, which is comprised of components that can be easily chosen and composed into a system for process planning.

NIST is interested in the development of a software component framework to enable agile process planning that suits users' specific needs. The objective is to develop a dynamic system specification mechanism and prototype component library that will assist in developing the concept of rapid software development to meet the market demands. We solicit proposals to develop the following elements of component-based process planning software: (1) a process planning system functional and data requirement specification mechanism; (2) a library of process planning software components with clear definitions of functions, input/output data, and applied rules to each component; (3) a knowledge-based mapping mechanism that maps components to process planning requirements; (4) an automated object composition mechanism; and (5) automated software validation procedures. The principles to be developed and

demonstrated in this project will be applicable to general software development, and the framework is extensible to other application domains in manufacturing.

8.9.11T SUBTOPIC: Laser Tracker Virtual Instrument

Developed at NIST in the mid 80's, the laser tracker, a three-dimensional interferometric based coordinate measuring instrument, is a relative newcomer to the field of coordinate metrology. It is rapidly gaining acceptance as the instrument of choice for many large-scale measurement tasks by the U.S. aerospace and automotive industries. In order to maintain competitiveness in the emerging worldwide economy, many of these industry's manufacturers and suppliers have begun implementing ISO 9000 quality systems and seeking ISO Guide 25 based measurement accreditation - both of which require traceability and hence measurement uncertainty estimates. Unfortunately, the laser tracker suffers the same difficulty as all three-dimensional coordinate measuring instruments when it comes to uncertainty estimation. The error mechanisms and the way these errors propagate through the measurements process is very complex and many times task specific. Ultimately, what is required is a software package for the modeling and real time prediction of task specific measurement uncertainty. To be valid, this model must include instrument specific contributions to uncertainty (some of which are manufacturer specific), ambient environment contributions, as well as task specific uncertainty issues such as sampling strategies, size and shape of the part, distance from tracker, etc. The successful developer should demonstrate strong programming skills, a background in coordinate metrology, and direct experience with laser trackers.

8.9.12T SUBTOPIC: Intrinsically Digital Mass Measurement Technique

Research is invited on promising approaches to truly digital mass measurement techniques which do not employ analog force measuring devices, such as strain gage load cells or other analog force measuring elements with close coupled sensing devices, such as oscillating crystals, capacitive, magnetic or magneto-elastic devices. Expectations from this research, compared with existing technologies, are inherently digital mass measurement, higher accuracy, lower cost, greater environmental reliability, and independence of the acceleration of gravity.

8.10 NIST TOPIC: CHEMICAL SCIENCE AND TECHNOLOGY

8.10.1T SUBTOPIC: A Novel Atomizer for Reference Spray Combustion Facility

Combustion of chemical liquid wastes depends critically on the quality of droplet atomization, and mixing of wastes within a surrounding air flow field. A reference spray combustion facility is under development that will be used to provide benchmark experimental data. The facility will be well-characterized, and provide standards for spray systems, instrument calibration, and validation of computational fluid dynamic models. Of critical need for this facility is an atomizer that will serve as a repeatable reference standard. A variety of methodologies can conceivably be applied to ensure optimum atomization. Novel strategies are sought to provide a well-controlled spray that has known size (polydisperse) and velocity distributions, as well as predictable droplet transport properties (i.e., dispersion and penetration), and residence time under burning conditions. An atomizer is needed that will: (1) produce different *a priori* specified droplet size and velocity distributions, with known number densities (SMD between 7 and 200 µm and up to $10^6/cm^3$, respectively), (2) be applicable to high-temperature operation (combustion), (3) produce droplet velocities up to 30 m/s, and (4) use conventional fuels (e.g., kerosene) at flow rates of up to 10 l/h.

Phase 1 of this research should demonstrate the feasibility of the proposed approach. The objective of Phase 2 is the delivery of a functioning device. It is expected that the availability of a controllable spray nozzle will find immediate commercial applications in spray nozzle and burner industries.

8.10.2T SUBTOPIC: Strongly Coupled CFD Code for Modeling of Spray Combustion Systems

An advanced computational fluid dynamics code (CFD) is needed for detailed modeling of the complex turbulent, two-phase, flow field of spray combustion systems, such as furnaces, boilers, and thermal oxidizers. Simulations are required via numerical modeling to serve as an interface between data obtained in a laboratory-scale experimental facility and full-scale processes. Models of interest will have to deal with two-phase reacting flows in which sprays, particulates (soot), and gaseous emission species will have to be dealt with in the code. Because of the significance of the coupling effects between the fluid dynamics, chemistry, and droplet behavior, such considerations must be included in the code. The spray submodel must provide spatially resolved information on the individual droplet size and velocity distributions, number density, droplet evaporation, and dispersion. In addition to droplet tracking, the submodel should handle both the droplet transport and dynamics. The code must handle polydisperse size distributions that have a wide range of sizes from 200 µm

down to submicron droplet sizes. The chemistry submodel must enable incorporation of full chemical mechanisms. The particulate submodel must handle particle growth and agglomeration, and impingement/deposition (thermophoresis, inertial, and turbulent diffusion effects) on the chamber surfaces. Other submodels for turbulence and heat transfer between the phases (i.e., droplets and environment) must also be available in the code. Other features to be included are 1) swirl, 2) three-dimensional configurations, and 3)adaptive gridding. Computational speed and efficiency, of course, will have to be demonstrated with respect to other currently available codes.

Phase 1 should demonstrate the feasibility of developing a code with the proposed features. The objective of Phase 2 is the delivery of a functioning code. It is expected that this new modeling capability will find immediate commercial applications for fuel spray combustors, power generation systems, and chemical processes involving combustion of liquid wastes.

8.10.3T SUBTOPIC: Particle Image Velocimetry (PIV) for Flow Measurement

Accurate, non-intrusive flow measurement techniques are needed at NIST to measure the flow distribution in turbulent pipe flow for liquids in closed conduits. Rapid detection of the spatial variation of fluid velocity over pipe cross sections enables computation of profile skewness and swirl, both of which are critical in assessing or monitoring flow meter calibration conditions. Profile skewness and swirl can significantly affect the performance of flow meters, and these profile characteristics can propagate considerable distances downstream from pipeline elements, such as pipe elbows, valves, etc., which produce these flow phenomena. NIST seeks research and development to extend current Particle Image Velocimetry (PIV) techniques to rapidly measure the fluid velocity distribution over pipe cross-sections in turbulent flows of transparent liquids. The desired system should be capable of producing spatial and temporal correlations of the resulting velocity information to assess profile characteristics and monitor bulk flow steadiness. The measurement accuracy goal for point velocities over the pipe cross-section is: (1) $\pm$ 1% or better in the ideal velocity distributions produced by long straight lengths of constant diameter piping, and (2) 2% or better for skewed and swirled pipe flows, such as those which flow from pipe elbows or valves. Phase 1 should produce a system design, an estimate of its uncertainty, and

a feasibility study of its capability to assess pipe flow profiles. A Phase 2 effort to develop a functioning prototype of the system will be considered based on the results of Phase 1.

8.10.4T SUBTOPIC: High Temperature Thin-film Insulation

High temperature (900 °C) thermometry and heat flux gages require high temperature thin-film insulators. The gages may employ noble metal thermoelements such as platinum, palladium, and rhodium alloys, or heat resistant nickel alloys. Although some success has been obtained using sputtered oxide coatings, several problems interfere with commercial applications. Commercial insulators are limited by low melting substrates, such as anodized aluminum, high cost sputtered oxide techniques, and pinholes and flaws in CVD and sputtered coatings. The ideal coating would be less than four micrometers thick; defect free, with a high dielectric breakdown voltage; inexpensive to deposit on a variety of metal substrates of various shapes; well bonded to the substrate and the thin film conductors above; and stable in the environment of the application.

Proposals are sought for innovative methods to achieve the fabrication of low cost, high temperature thin-film insulators. These insulators should be capable of electrically insulating thin-film sensors from metallic substrates at temperatures ranging up to 1100 °C, with a thickness of less than four micrometers. The thin-film insulator should be compatible with stainless steels, high temperature nickel-based alloys, and noble metals, such as platinum and palladium. Application in the temperature range of 500-800 °C are also important and will be considered. The planned project should demonstrate the fabrication of the thin-film insulator on suitable substrates, including silicon, for thermocouples and heat transfer gages and demonstrate, also, the performance of the insulating film. A plan for commercialization of the process is also important.

8.10.5T SUBTOPIC: Mid-Infrared Light Source for Cavity Ring-Down Spectrometer

NIST is developing cavity ring-down spectroscopy as a quantitative method for making accurate and precise measurements of gaseous contaminants in ultrahigh vacuum environments and process gases. For optimal sensitivity, mid-infrared laser sources are needed. For optimal impact, these sources should be simple and rugged enough for use in industrial environments. Target gases include H_2O, O_2, CO_2, CO, and CH_4. The ideal laser would be tunable to one or more absorption resonances of several of the target gases; a Phase 1 project should focus on the 1.4 µm (v_1+v_3) or 2.7 µm band (v_1 and v_3) of water and the 1.3 µm band ($a \leftarrow X$) of oxygen. This source could be pulsed, with a pulse duration of 10-50 ns, a repetition rate of $\geq$1 kHz, and an output power of

≥100 mW in a TEM_{00} mode. The output radiation should have a spectral bandwidth of ~100 MHz, and a frequency drift of ~100 MHz per hour. The laser should be operable for extended periods without the intervention of skilled personal, and it should be rugged, spatially compact, air cooled, and run on 110 V_{AC} electrical service.

8.10.6T SUBTOPIC: New Technology Detectors for Analytical X-ray Spectrometry

NIST has a long standing interest in analytical X-ray spectrometry, with excitation beams of electrons or photons. Energy dispersive X-ray spectrometry (EDS) is generally preferred, due to its capability of viewing the entire X-ray energy spectrum and, therefore, of performing a complete qualitative analysis at each beam location. Existing EDS detectors, based on large monolithic semiconductor crystals (Si, Ge) are limited in resolution (130 eV for Si; 120 eV for Ge, both at 5.89 keV, Mn K-alpha), in photon processing speed (about 3,000/s at the best resolution), and size (10 square mm for the best resolution). Additionally, these detectors must be cooled to approximately 100 K, which places constraints on their integration into complex electron beam systems, such as microscopes.

NIST is interested in developing analytical X-ray spectrometry, based upon other possible approaches to X-ray detection. Recent presentations at scientific conferences have suggested the possibility of using detectors based upon silicon drift technology, which have the possibility of higher resolution, larger surface area (100 square mm), much higher rates of photon processing (> 100,000/s), and operation at or near room temperature. NIST, therefore, seeks proposals to develop the methods of fabricating practical detectors for analytical X-ray spectrometry based upon this or similar concepts.

Reference:

Strudar, L. 1997. High Resolution Non-Dispersive X-ray Spectroscopy with State of the Art Silicon Detectors. European Microbeam Analysis Society, May 15.

8.10.7T SUBTOPIC: Telepresence Electron Microscopy and Microanalysis Systems

NIST solicits proposals for the development of methods to connect sophisticated electron microscopy and microanalysis instrumentation to remote collaborators and users, based upon any of several different levels of communication technology, ranging from basic television signal transmission via modem/telephone lines to the high speed ATM network capabilities. In recent years, intensive efforts by manufacturers have established local control systems for computer-assisted operation of these instruments, especially the imaging and microanalysis features, such as electron imaging systems,

X-ray spectrometry, and electron energy loss spectrometry. Development of the methodology, software, and interfacing protocols to establish long distance observation and operation that will enable effective collaborations to operate in real time, between scientists and engineers located in industry, academia, and national laboratories.

Electron microscopy and microanalysis is a critical measurement technique that has a major impact on the development of new materials, development and trouble shooting of processing and manufacturing for materials and devices, and failure analysis of finished products. Measurements include micrometrology of two- and three-dimension spatial features, chemical characterization of elemental species and compounds in the microstructure at the micrometer to nanometer spatial scales, and crystallographic (phase) determination. Critical industries affected include primary users as diverse as semiconductor devices, communications, petroleum, and pharmaceuticals, and secondary users such as aircraft (e.g., failure analysis), fluid power (particle loading in engine oil), and biomedical (e.g., device-tissue interactions). Implementation of these techniques typically requires capitalization at $0.5 - $2.5 million per commercial instrument, plus additional costs for Ph.D. level personnel to operate, or direct, the use of the instruments. As a result, only the largest companies can afford to directly purchase and implement these techniques "in house", and then only at central R&D facilities, remote from at least some of their manufacturing centers, while smaller companies are nearly always forced to use remote suppliers of analytical services. NIST solicits proposals for the development of computer control and communication capabilities to implement "telepresence" microscopy and microanalysis, whereby instruments can be monitored in an "over the shoulder" mode of operation and analysis with collaborators and, in some cases, the instruments operated by remote users. Successful development of telepresence operation will bring important capabilities and new efficiencies to U.S. industry, and new measurement strategies to NIST. Telepresence capabilities will be of particular value to commercial providers of "service analysis" by greatly improving connections to customers.

8.11 NIST TOPIC: PHYSICS

8.11.1T/A SUBTOPIC: Artifact for Characterizing Scanning Surface Inspection Systems

Commercial scanning surface inspection systems, or wafer scanners, rely upon optical scattering to determine microroughness and particulate contamination parameters of silicon wafers. However, due to its unique optical geometry, each instrument is sensitive to a different range of spatial frequencies of surface microroughness, with a different sensitivity to each spatial frequency within that range. Furthermore, that sensitivity may change over time, due to aging or misalignment of the optics.

NIST seeks proposals for development of an artifact which would allow the spatial frequency response function for a scanning surface inspection system to be measured. An example of such an artifact may take the form of a silicon wafer on which has been patterned a series of gratings of known amplitudes spanning a range of periods and orientations. The number of different periods and orientations would have to be sufficient to characterize any commercially available system, and the scattering levels must be sufficiently low so as to not saturate the system being characterized. Other configurations are possible, but sufficient information must be available to obtain the response function for isotropic microroughness.

Microroughness is also extremely important in the quest for increased storage capacity and smaller disk-drives. For example, if the surface roughness is increased, then the flying height needs to be increased to prevent head crashes. Since flying height is the primary factor that determines practical areal recording density, this limitation is a serious barrier to further improvements in storage capacity for digital data storage drives. ATP has funded approximately a dozen projects in data storage technology. Most, if not all, require attention to roughness of heads, media, and substrates. A microroughness artifact would be valuable for the data storage community that is seeking uniform metrology to achieve smoother and flatter head air-bearing and disk surfaces.

8.11.2T/A SUBTOPIC: Bidirectional Ellipsometer for Surface Inspection

The quantity of light scattered by a material is often a useful measure of the quality of its surface or bulk. However, it is usually difficult to unambiguously determine the source of scatter, be it from surface microroughness, subsurface defects, or particulate contamination, just from measurements of the intensity of the scattered light. The

polarization of the scattered light, on the other hand, contains information about the sources of scatter, since it more strongly reveals the path the light followed during its trajectory. The technique of bidirectional ellipsometry, whereby the polarization of light scattered by a sample is measured in directions out of the plane of incidence, has been found to discriminate between light scattered by particulate contamination, subsurface defects, and microroughness. Predictions for polarized light scattering in dielectric films and simple structures on silicon or metal surfaces have suggested that bidirectional ellipsometry will also prove powerful for characterizing defects in layered or patterned materials.

Proposals are sought for the development of instruments which will allow industry to rapidly make use of bidirectional ellipsometry for the characterization of defects in materials. Numerous commercial instruments exist for performing spectroscopic or multiple-angle ellipsometry, and these instruments are used regularly for the measurement of thin film thicknesses and dielectric constants. Due to the novelty of bidirectional ellipsometry, no commercial instruments exist at this time for readily performing it.

Integration of optical and electronic devices on a single chip in the form of an OptoElectronic Integrated Circuit (OEIC) promises to produce products that are more reliable, more complex, faster, and more affordable than ever before. Optical thin films of non-linear optical materials such as lithium tantalate are used in the construction of optical devices, much in the same way that electronic integrated circuits are assembled using existing semiconductor technology. Optical waveguides, switches, modulators, and second harmonic generators are components of the optical devices that will have a tremendous influence over future developments in both communications and computing applications. However, the performance of these nonlinear devices may be severely degraded by scattering mechanisms. Bidirectional ellipsometry may be a powerful tool to gain insight into these degradation mechanisms. In addition, the technique may be useful in characterizing other factors that may increase attenuation of the guided wave, such as optical absorption, porosity, and refractive index inhomogeneities, such as those found in polycrystalline materials. ATP has funded several projects which developed nonlinear optoelectronic components for wavelength multiplexing signals through optical fiber communications systems and the frequency doubling of light for applications in high-resolution displays, optical storage devices, and printing applications.

8.11.3T/A SUBTOPIC: Microfabricated Cantilever Probes for Combined Near-Field Scanning Optical and Atomic Force Microscopy

Near-field scanning optical microscopy (NSOM) is rapidly becoming a useful technique for nanoscale optical characterization of materials. NSOM makes use of the properties of a sub-wavelength optical probe to exceed the diffraction limit in optical microscopy. Images are constructed by scanning the probe over a surface at distances much smaller than a wavelength of light. Contrast is generated by way of a number of different interactions of the sample and probe, including such traditional optical contrast mechanisms as absorption, reflection, fluorescence, and polarization, and also new contrast mechanisms that are unique to NSOM, including dielectric contrast. Probes currently in use for this purpose include single mode glass optical fibers drawn to a fine point (about 50 nm) and usually partially coated with aluminum, and small metallic scatterers.

NIST is seeking microfabricated aperture, waveguide, or combination aperture/scatterer NSOM probes in a form that is compatible with atomic force microscopy (AFM). These probes should be useable as contact, noncontact, or intermittent contact probes in commercially available atomic force microscopes, but should have the additional feature of a small subwavelength aperture or tapered waveguide structure for guiding and confining light. Waveguide or aperture probes with a small scatterer at the tip will also be considered.

Newer data storage devices are exploring the concept of recording more than one bit of information per physical location on the media. For example, one project funded by ATP relies on a variable-depth pit in a substrate to encode information in a very dense array of spots similar to those on a CD-ROM. The cantilever probes for combined near-field scanning optical and atomic force microscopy may lead to a powerful combination of measurement and diagnostic tools that will have market applications in the data storage industry.

8.11.4T/A SUBTOPIC: Standard Reference Materials and Resolution Test Patterns for Characterization of Scanning Near-Field Optical Microscopes

Near-field scanning optical microscopy (NSOM) is rapidly becoming a useful technique for nanoscale optical characterization of materials. NSOM makes use of the properties of a sub-wavelength optical probe to exceed the diffraction limit in optical microscopy. Images are constructed by scanning the probe over a surface at distances much smaller than a wavelength of light. Contrast is generated by way of a number of different interactions of the sample and probe, including such traditional optical contrast

mechanisms as absorption, reflection, fluorescence, and polarization, and also new contrast mechanisms that are unique to NSOM, including dielectric contrast. Because of these optical contrast mechanisms, NSOM could have significant applications in metrology for magnetic and optical data storage materials, particularly in cases where STM or AFM contrast mechanisms may not be applicable.

NSOM probes currently in use include single mode glass optical fibers drawn to a fine point (about 50 nm), and usually partially coated with aluminum and small metallic scatterers. Probes can be used either for collection of light or for illumination of the sample. Resolution in NSOM depends on the size and efficiency of the probes, and is intimately tied to the contrast mechanism used. No standard techniques or materials exist for determining the resolution and characterizing the contrast mechanism of these probes.

NIST is seeking proposals for development of suitable reference materials and resolution test patterns to determine the resolution and characterize the contrast mechanisms of near-field probes. Suitable materials will have nanoscale optical features that have little or no topography, and will be useful for characterizing probes used in reflection, absorption, polarization, fluorescence, or dielectric contrast.

8.11.5T/A SUBTOPIC: Attenuated Total Reflection (ATR) for Far-Infrared Spectroscopy

Research into novel spectroscopic applications of far infrared radiation (THz regime at >50 microns or <200 cm-1) is of current interest to NIST, industry, and academic research groups throughout the US. Included in these rapidly growing areas is the ability to detect minute transmission changes (0.1% change or less per reflection) of weakly absorbing thin films, organic and biochemical monolayers deposited on transmissive substrates, or of molecular systems dissolved in highly absorbing solvents. A widely-used, generic approach for obtaining high sensitivity, broadband mid-infrared spectra (2-25 microns) of these sample types with commercial FTIR instruments employs attenuated total internal reflection crystal accessories (ATR's). These devices are designed to accept radiation via FTIR transfer optics and permit multiple reflection passes of the infrared beam through appropriately cut ATR crystals in contact with the sample. Typical crystals used in mid-IR work include high refractive index ZnSe, Ge, or KRS-5 glass, which are only transmissive to <25 microns.

Proposals are sought for development of an ATR-type device for far-infrared spectroscopy of organic and biochemical monolayers adsorbed on silicon-oxide or other oxide substrates. The goal of this SBIR is to design and engineer an appropriate ATR crystal substrate to obtain the maximum number of reflection passes in a minimal crystal path length, and reduce beam walk-off and divergence through the crystal path

at long IR wavelengths. The device must couple to a commercial far-infrared FTIR or collimated broadband radiation generated by a laser-based THz system. One possible material is high purity silicon which provides minimal transmission loss, has a high refractive index and is capable of surface modification to form silicon-oxide. Other materials are also possible, as would unique designs with compensating input and output focussing optics to maintain beam collimation and throughput. It is envisioned that an accessory of this type, currently unavailable on the commercial market, will become desirable and widely used in future FTIR systems.

8.11.6T/CC SUBTOPIC: High-Resolution Two-dimensional Active Electronic Neutron Detectors

NIST uses two-dimensional neutron imaging detectors for several important applications: neutron radiography, neutron tomography, neutron phase contrast imaging, small angle neutron scattering, neutron reflectometry, and neutron beam diagnostics. In most of these applications where active electronic imaging devices are employed, improved resolution is very badly needed. Ironically, microchannel plate neutron detectors were first developed at NIST and received a R&D100 Award, but now we have to import them from Germany and Russia, due to lack of commercial development in the United States.

NIST has purchased several of these microchannel plate devices with 40 µm resolution from a German supplier, and we have borrowed a 9 µm resolution microchannel plate detector of Russian origin from a German collaborator. Our most demanding current use of these two-dimensional imaging devices involves high-resolution radiography of hydrogen fuel cells, which are being developed for new-generation automobile power sources.

The objectives of proposals on the subtopic should be to develop active electronic neutron detectors and fabrication techniques which provide improved resolution, improved efficiency, larger active area, and reduced cost.

Passive image accumulation devices are also of interest to NIST, but current products of this kind are already much more satisfactory, and the present subtopic pertains only to active electronic devices.

8.11.7T SUBTOPIC: Analysis Software for Near-Field Scanning Optical Microscopes

Near-field scanning optical microscopy (NSOM) shows great promise as a new optical microscopy which can provide resolution much better than the diffraction limit. In NSOM, a single-mode optical fiber is pulled and tapered to a tip and then coated with metal, leaving a small nm-scale aperture at the tip end. This tip can act either as a nm-scale source or collection aperture. When the tip is placed a few nanometers from a sample, nm-scale resolution can be obtained. NIST currently has a long-term program to develop NSOM and to exploit it in metrological applications.

The optical interaction between the probe tip and the sample occurs in the near-field regime. As a consequence, rapidly varying evanescent fields make critical contributions, and the tip and sample are strongly coupled by the fields. New paradigms and simulation capability must be developed to analyze optical microscopy in the near-field regime. No routine quantitative near-field microscopy can be done until the software tools are available for system optimization and control, and data analysis and interpretation.

NIST is seeking innovative approaches that can be developed as software products. Such approaches should provide full three-dimensional modeling of the vector electromagnetic fields in an interacting tip-sample geometry by the solution of Maxwell's equations. The optical response of the tip and sample should be modeled by complex dielectric response functions. The approaches should be able to treat a wide range of tips and a variety of samples, including, for example, optical waveguide devices, periodic and structured arrays of dielectric objects, isolated molecules, and quantum nanostructures. The approaches should be able to model the images, typically detected in the far field, that are generated by the near-field tip-sample interaction, and account for the transfer of probe light from far-field sources into the tip-sample interaction region. A key challenge is to develop approaches that are efficient and robust, so that simulations can be used to analyze data and optimize microscope operation in near real time. It is expected that innovative approaches will be developed that exploit the power of sophisticated numerical techniques, such as finite difference and finite element methods, needed for three-dimensional solutions of the vector Maxwell equations for complicated structures, while providing the efficiency and robustness needed in an effective simulation tool.

8.11.8T SUBTOPIC: Vacuum Near Field Optical Microscope

For a variety of measurement applications in nanometer scale semiconductor devices, such as measurements of photoluminescence, study of wafer defects, and examination of photoresist materials, an ultrahigh vacuum near field optical microscope instrument is required. The design of the instrument must incorporate standard optical fiber tapered tips with easy interchange of both tips and samples under vacuum. The instrument must incorporate shear force topographic imaging, vibration isolation, and high efficiency light collection in transmission and reflection modes of the near field optical microscope. A resolution of 100 nm is desired. The near field instrument and its vacuum chamber and pumping system will be mated to standard surface science ultrahigh vacuum equipment used for deposition and analysis, with compatible load lock sample introduction and transfer. In Phase 1, a complete engineering design of the vacuum near field optical microscope and its associated vacuum chamber, sample and tip manipulation devices will be required as a deliverable. In Phase 2, delivery of a working vacuum near field optical microscope, associated electronics and software, and representative data scans would be required.

8.11.9T SUBTOPIC: Advanced Ion Beam Methods for Nanotechnology

Ion beams are finding increasing application in various subdisciplines of nanotechnology, including:

1. Microelectronics: A typical microelectronics production line uses ion beams in over a dozen separate fabrication steps. In addition to conventional ion implantation methods, which have been in use for decades to form bipolar transistor bases, more modern uses include trench isolation, preamorphisation, proximity gettering, well engineering, and ion beam synthesis of buried layers. In addition, ion beams are used in microelectronics prefabrication to help construct working prototypes, and in post-production to diagnose failure. Future applications for online diagnostics and reduced-dimensionality lithography are envisioned.

2. Biotechnology: Material damage caused by the passage of a single energetic ion can produce nano-scale pores in materials, which can be used in the production of selective membranes for drug delivery and other applications in biotechnology.

3. Photonics: Production of advanced flat panel displays, diode lasers, and optical waveguides are examples of areas in which ion beams are showing increasing promise. Although miniaturized photonic devices typically have overall dimensions greater than one micron, they often rely on nanoscale uniformity or substructure.

NIST is seeking proposals for innovative ways to produce and apply ion beams for use in the general area of nanotechnology. Work should be geared toward results that lead to significant device performance improvements or lower manufacturing cost when compared to established alternative methods. Proposals which take into account the effect of varying the ion charge are particularly encouraged.

References:

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Reber, N. et al. 1995. Thermal Switching of grafted single ion tracks. Nucl. Instrum. Meth. Phys. Res. B, **105**, 275.

Polman, A. et al. 1995. Ion beam synthesis of planar opto-electronic devices. Nucl. Instrum. Meth. Phys. Res. B, **106**, 393.

8.11.10T SUBTOPIC: Quantitative Software Modeling and Verification of Roughness-Dependent Emissivity for Rapid Thermal Processing

In the rapid thermal processing (RTP) of silicon wafers, temperature and temperature uniformity are critical measurements that depend on an accurate knowledge of the emissivity of the wafer surface over a wide range of temperatures, angles, and radiation wavelengths. The emissivity, in turn, is a complicated function of the surface roughness, which can result in non-uniform radiative cooling of the wafer and create temperature non-uniformities. If the wafer surface is perfectly smooth, the emissivity is simply one minus the Fresnel intensity reflection coefficient. Real surfaces, however, are rough to some degree, and roughness affects the emissivity in a complicated way. NIST is seeking analytical software models to relate roughness variations to emissivity for a range of roughness values (appropriate to silicon wafer backsides and smoother) between 1 μm and 20 μm from 20°C to 1000°C. In addition, NIST is seeking corresponding experimental roughness and radiometry measurements to validate the analytical models.

8.11.11T SUBTOPIC: Actively Quenched IR Avalanche Photodiode

High efficiency stable photon counting devices are important for many areas of research, ranging from optical metrology, low level sensing, cryptography, and communication. All of these areas have needs in the infrared, where high quality detection is difficult to find. NIST is soliciting proposals to develop actively quenched compact photon counting modules for the spectral region from 1 to 1.5 microns or beyond with peak efficiencies of at least 50%. Such a unit would be similar to the Si-

APD based devices which have recently become available, but would likely use Ge or InGaAs avalanche photodiodes. The unit would employ an actively quenched bias circuit to reduce the avalanche recovery time, making counting rates of 1 MHz possible. The active area should be no smaller than 0.2 mm and have a dark count rate not exceeding 1 KHz. The units may use compact self contained thermoelectric cooling to produce low dark counting rates.

8.11.12T SUBTOPIC: Compact CW UV Laser Source

Solid-state laser sources are needed to replace cumbersome ion lasers as CW UV laser sources. Reductions in size of an order of magnitude and improvement in overall efficiencies of as much as three decades would greatly increase the convenience of light sources in this range and open up many new applications that are currently not possible. We are soliciting proposals for a system to produce coherent light in the range from 200 to 400 nm at power levels of 300 mW or greater. Within that spectral range, output at 213 nm, 266 nm and 355 nm, the tripled or quadrupled and quintupled output of NdYAG are of particular interest, although output at any UV wavelength will be of great utility and, of course, tunability would enhance the utility even further. The bandwidth requirement of the system should be 0.1 nm or less with fluctuations of the output power not exceeding 1%. The final device may operate by up-converting the output of existing compact solid state light sources, or may directly generate the UV if some appropriate scheme can be found. If a frequency conversion arrangement is used, the ultimate device may be integrated with the pump laser, or may be a compact add-on accessory to an existing compact light source.

8.11.13T SUBTOPIC: Line Emitting Surface LED

A commercially available line emitting surface LED would find numerous users. The source geometries now available are circular area source or square source. The availability of a small and bright line source would greatly facilitate (and make more energy efficient) the use of LED sources in a variety of position sensors. The use of an LED imaged onto a split photocell via a lens attached to the part whose motion is to be sensed (with the usual interest being in sensing motion along some particular dimension) makes an extremely sensitive and convenient one-dimensional position sensor. In our precision measurements laboratory, we have achieved motional sensitivity of 10^{-11} m for an integrating time of 1 second. However, were the "round" emitter geometry linear (a line) rather than round, we could use all the photons effectively. A desirable aspect (width to height) ratio would be something between 10 to 1 and 30 to 1. A source geometry of .005" high by 0.12" wide would be excellent.

8.11.14T SUBTOPIC: Liquid-Nitrogen-Cooled Electrical Substitution Radiometer

Electrical substitution radiometers enable accurate measurements of optical power to be made using electrical measurements, and form the basis of detector-based radiometric scales at several national standards laboratories, including NIST. They work by substituting a measured quantity of electrical heating power for optical power in alternate cycles. Room temperature versions, based on pyroelectric sensors, are available commercially, but have limited sensitivity for a growing number of applications. Liquid-helium versions are also available commercially, providing plenty of sensitivity, but at a much larger operating expense. A liquid-nitrogen cooled electrical substitution radiometer could offer a welcome compromise between sensitivity and operating expense, provided it had a high enough performance level. Typical performance specifications for a viable product should be: operable with chopped optical power with a 3 dB rolloff point of 80 Hz or greater; use of chopper synchronized electrical substitution; 5 mm or greater detector active area; spectral flatness less than 2% over a spectral band from visible to 20 micrometers; reflectance less than 1% (using, for instance, gold black and/or an optical trap); noise-equivalent-power of 10 picowatt per root Hz or less; maximum power level of 100 microwatts; and stability of response of 1% or better.

8.11.15T SUBTOPIC: Durable Ultra-Black Optical Coatings

Black absorbing coatings are used to coat optical baffles and thermal-type optical detectors. As infrared cameras, for example, are used in increasingly rugged environments, the need for durable black coatings is increasing. A coating process is desired which can coat irregular shapes, have greater that 90% absorbance over the spectral range from UV to far-IR, and can withstand long exposure to ultraviolet solar radiation without decreasing the absorbance. An absorbance mechanism based on surface morphology rather than on black dyes would seem to offer the best solution, and thus coating processes that produce particularly rough, black surfaces are desired.

8.11.16T SUBTOPIC: Ultraviolet Detectors And Optical Components

Proposals are sought for development of new ultraviolet detectors and ultraviolet optical components. These devices and components are needed because NIST has requirements to calibrate ultraviolet irradiance and radiance detectors in the spectral range of 100-400 nm for lithographic, environmental, uv processing, and space applications. These applications require uv detectors that are uniform in responsivity across the detector area and stable with time and UV dose. Also desirable are solar-blind and position-sensitive (array) UV detectors. Inseparable from the requirement for improved UV detectors is the need for UV optical components such as cutoff filters,

diffusers, and optical fibers that resist degradation under high or prolonged exposure. Commercially available components presently have poor uniformity, stability, and UV damage resistance, making it difficult to maintain calibrated instruments and transfer standards. It is also important for detectors in this spectral range to have a wide dynamic range (low noise and good linearity) and low temperature dependence of the responsivity. NIST desires the development of materials and components which have prospects for advancing the state-of-the-art.

8.11.17T SUBTOPIC: Platinum Silicide Photodiode Detectors for the Extreme Ultraviolet (Standards Quality)

NIST has been a source for radiometric transfer standard detectors for the extreme ultraviolet (EUV) spectral region for many years. Recent developments have made possible the use of radiation-hardened silicon photodiodes in this program. It is felt that the stability of NIST EUV standards can be further improved by the development of suitable detectors using platinum silicide Schottky barrier construction. Fundamentally, these would consist of a thin (<10 nm) layer of platinum silicide on n-type silicon, with a windowless configuration.

The detectors should have an active area of at least 1 cm by 1 cm, and would be used by NIST primarily in the 3 nm to 254 nm spectral region. Important parameters for NIST standards applications include a high degree of spatial uniformity and temporal stability, a low level of internal noise, and freedom from damage by radiation in the extreme ultraviolet/soft X-ray region. NIST personnel can assist in the evaluation of developed detectors in these areas.

8.11.18T SUBTOPIC: UV Fluorescence Imaging System for Spatially Selective Identification of Radicals/Molecules Important to Silicon Wafer Processing

The need for UV imaging of gas phase molecules and radicals is crucial for process monitoring in the semiconductor industry. Laser assisted or direct plasma emission from process gases is used to uniquely identify important free radicals/molecules used during etching or layering of semiconductor wafers and as a process monitor of chemical contaminants. Features of UV methods include its low background and high sensitivity (single photon detection), and fast detection of emission when used in conjunction with laser based methods. Present direct UV absorption methods provide quantitative information about these species in the form of column integrated intensities

and, thus, lack the spatial information content necessary to ensure uniform process control across the surface of the wafer.

NIST seeks proposals for innovative UV fluorescence imaging systems for spatially selective identification of radicals/molecules important to silicon wafer processing. The need for high spectral image quality on the order of 25-50 µm can be met with the use of a UV fluorescence imaging system, consisting of a UV imaging photomultiplier and spatially selective reflective optical system. The development of such a system will be invaluable to the growing need for process growth uniformity in the semiconductor wafer industry.

8.11.19T SUBTOPIC: Superconducting Quadrupole Magnet for Trapping of Ultra-cold Neutrons

NIST participates in a program of fundamental research to develop an ultra-cold neutron source. This work uses neutrons generated at the reactor facility at NIST, Gaithersburg. This new type of source is applicable to neutron beta-decay research as well as neutron scattering for materials research. The source operates using superfluid helium as a superthermal moderator and a magnetic trap to confine the neutrons.

The magnetic trap consists of two solenoids and one cylindrical quadrupole magnet. The cylindrical quadrupole magnet is the most challenging part of the apparatus. Although some work has been done in developing air-core superconducting quadrupole magnets, the technology still requires research and development. Theoretically, a trap depth of 3 Tesla or above should be attainable. Such magnets would be useful in many other areas of physics including atomic physics and atomic clocks.

The objectives of proposals on the subtopic should be to develop a viable design and construct a prototype for a 1.2-meter long, 8-cm diameter bore, air-core, >2.5 Tesla deep superconducting quadrupole magnet.

8.11.20T SUBTOPIC: Water Calorimeter for Accelerator Radiation Beam Therapy Dosimetry

Of the approximately 1 million cancers diagnosed each year, about 60% of the patients receive radiation therapy. In addition to ^{60}Co gamma-ray teletherapy sources, the radiation beams used are increasingly from electron accelerators, both in the form of the direct electron beam or in the form of high-energy photon beams, produced by converting the electron energy to bremsstrahlung in a converter plate. Therapy with such sources are performed in over 1300 clinical facilities in the US. Proton accelerators are used at two US clinical centers for the treatment of certain cancers. The absorbed dose to tumor volumes is typically 1-3 Gy per treatment; electron beam

energies are typically from 7 to 35 MeV, photon beam endpoint energies can be in the range from 6 to 30 MeV, and proton beam energies are typically from 50 to 250 MeV.

It is critical to the success of the therapy that the absorbed doses to the tissue be known accurately. The radiation doses at each facility are assured through measurements with calibrated instruments. These instruments are usually ion chambers (measuring the ionization of air by the radiation), but calibrated in terms of absorbed dose to water (a tissue-equivalent material) through calibrations traceable to NIST standards for ^{60}Co radiation. The calibration chain proceeds by a complicated protocol, based on a series of correction factors, to convert air ionization from ^{60}Co radiation to absorbed dose in water from the beam quality of interest, which contributes to uncertainties in the clinical measurements. New protocols for therapy dosimetry in US clinics will be based on primary calibrations performed directly in terms of absorbed dose to water measured by calorimetry; future trends will be toward direct, absolute absorbed-dose measurement in the wide variety of beam modalities and qualities.

The temperature rise in a water calorimeter can provide a direct, absolute measurement of the energy absorbed in water due to the radiation. A significant body of research addresses the application of water calorimetry to ionizing radiation dosimetry, the most successful of which is perhaps the work of Domen at NIST. Research and development is needed for a water calorimeter system suitable for absolute dosimetry of the radiation beams from clinical accelerators, for use at NIST in our radiation standards and calibrations program, and with potential for use at secondary dosimetry calibration laboratories, as well as at the clinical centers. The research and development should address factors pertinent to such a system, such as the accurate measurement of the small temperature rise, thermal leakage, excess heat in constituent structures, the heat defect of the water in the detector volume, motion and temperature variation of the water surrounding the detector volume, construction of appropriate housings and windows for use with accelerator beams, and control and data-acquisition systems.

8.11.21T SUBTOPIC: Monte-Carlo Interface

Non-invasive high-energy photon measurements for a multitude of applications depend on accurate instrument calibrations. The objects to be measured, however, can be very complicated and difficult to reproduce with reference materials (e.g., radionuclide distribution, matrix effects, geometry). Monte Carlo calculations offer an attractive virtual-reality alternative to physical reference materials. The major obstacle to using Monte Carlo techniques, however, is laboriously defining the geometric and material model for the environment and samples to be evaluated. What is needed is an interface software that is able to convert an AudoCad.XXX type description of the geometry and material characteristics directly into MCNP-4A (a widely-used Monte

Carlo software for radiation) for program implementation. The program should be coded in C, user friendly, and seamless between AutoCad.XXX and MCNP-4A. Presently, simplistic Monte Carlo programs are used only by specialists because of the complicated nature of defining the radiation environment. The requested software will allow wider use of the powerful Monte Carlo technique for much more sophisticated and complex applications. The software will open new commercial opportunities for radiation measurements, and associated disciplines.

8.11.22T SUBTOPIC: Automated Glow-Discharge Source for Mass Spectrometric Counting of Radionuclides

NIST is responsible for the development of low-level, natural matrix standards, and the correct application of these standards to environmental radioactivity measurements. A glow-discharge source has been investigated at NIST for use in mass spectrometric measurements of radionuclides, and shows significant potential for highly sensitive measurements using little or no radiochemistry.

This proposal is to develop a glow discharge source, or equivalent, or better, with optimization of the basic parameters, to give acceptable sensitivity, and to develop a commercially useful design that can incorporate environmental samples on an automated basis. Such a device has enormous potential commercial value, since a significant fraction of future environmental measurements will be performed by mass spectrometry systems, and this device could be crucial in developing an automated mass-spectrometric system.

The device would be coupled to a Resonance Ionization Mass Spectrometry system which uses c.w. lasers for the atom selection. The aim is to provide a mass selection in the 10^{-13} range.

8.12 NIST TOPIC: MATERIALS SCIENCE AND ENGINEERING

8.12.1T/A SUBTOPIC: Development of Particulate Control in Pulsed Laser Deposition of Thin Films

Pulsed laser deposition is an emerging technique for the production of complex novel thin films of interest to the semiconductor and photonics industries. Commercialization of pulsed laser deposition is limited in part by particulate formation during the

deposition process. The elimination of these particulates is crucial to the incorporation of these complex films in integrated circuit devices. Innovations are needed for the control and elimination of particulates during the pulsed laser deposition process.

8.12.2T/A/I SUBTOPIC: Software for Analysis of Acoustic Microscope Signals

According to U.S. Patent Number 5549003, obtained in 1996 by the Metallurgy Division of NIST, the shear acoustic mode created at a water/solid interface by mode conversion and propagation in the solid is sensitive to residual or applied stresses in the solid. The feasibility demonstrations of stress measurements using this effect were first published in JASA and in Nature. The major obstacle which impedes this technique from becoming a routine tool for stress measurement by use of an acoustic microscope is the technical difficulty of separating the longitudinal wave reflected twice from the shear wave reflected once, since these waves arrive simultaneously at the receiver. The interference problem for birefringent shear waves propagating in the material under stress has been solved, and the amplitude dependence on stress has been predicted quantitatively, but it is still very difficult to separate the shear from longitudinal modes in the receiving pulse. If this difficulty can be overcome, ambiguities caused by an additional interference of the two split shear modes with the longitudinal wave will disappear. Proposals are sought for development of software implementing an original concept of filtering the longitudinal wave from the shear mode by applying the FFT (Fast Fourier Transform) to the two acoustic modes created by the coherent source (the longitudinal angular pulse entering the material from water) during the mode conversion. This concept has been implemented and tested at NIST. Development of effective software would create a new capability for measurement of the residual stresses in solid materials and would implement a novel aspect of solving the filtering problem for acoustic microscopy.

References:

Drescher-Krasicka, E. U.S. Patent 5549003.

Drescher-Krasicka, E. Journal of the Acoustic Society of America, 94, 453-464,93.

Drescher-Krasicka, E. and J.R. Willis. 1996. Nature, Vol 384,
pp 51-55.

8.12.3T/A SUBTOPIC: Improved Magneto-Optical Indicator Films

The magneto-optical indicator film (MOIF) imaging technique is a non-destructive method for real time characterization of magnetic domain structure for a wide range of

technologically important magnetic materials, such as spin-valves, ultra thin multilayers, and granular systems. The MOIF film is placed on top of a magnetic sample and has its magnetization altered by the magneto-static field of the sample under study. The domain structure of the magnetic sample can then be imaged in a polarizing microscope through the interaction of polarized light with the MOIF film. The MOIF method is expected to become a standard non-destructive quality control imaging technique for the next generation of magnetic materials for sensors and storage devices. Proposals are solicited for the development of improved magneto-optical indicator films, including, but not limited to, transparent bi-substituted yttrium-iron garnet single-crystal films (thickness 1 - 3 micrometers, Faraday rotation > 100,000 deg/cm), with a reflective Al underlayer grown on a gadolinium-gallium garnet substrate. The influence of different element substitutions should be studied to enable films with different magnetic saturations and sensitivities to be fabricated.

Reference:

Gornakov, V.S. V.I. Nikitenko, L.H. Bennett, H.J. Brown, M.J. Donahue, W.F. Egelhoff, R.D. Mc.Michael and A.J. Shapiro. Experimental study of magnetization reversal processes in a nonsymmetric valve. J. Appl. Phys. 81. (8) 5215.

8.12.4T/A SUBTOPIC: Advanced Measurement Technology for Characterizing the Dimensional Stability of Thin, Small Area Dielectric Films

It is no longer unusual for semiconductor packages, interconnect substrates, or other electronic subsystem to incorporate a wide variety of materials with thickness dimensions ranging from a few hundred nanometers to tens of microns. These developments, in conjunction with the diversity of materials being utilized, requires a concurrent availability of suitable measurement tools for the characterization of material properties, and the determination of product-process interrelationships on a scale commensurate with device feature size. These materials characterization data underpins product design specifications and reliability.

This SBIR subtopic solicits proposals for the development and commercialization of measurement equipment for the characterization of the coefficient of thermal expansion, CTE, and/or hygrothermal expansion for very thin, very small area polymer and other dielectric materials. Tools should be suitable for measuring out-of-plane or in-plane characteristics, and allow sensitive, accurate determination of fundamental material parameters for materials not to exceed 50 micrometers in original thickness, or 100 micrometers in length.

NIST capabilities in thin film z-axis dimensional stability measurements can be made available to appropriate awardees.

8.12.5T/A/CC SUBTOPIC: Next Generation Electronic Materials for High Temperature Automotive Electronic Packaging

Cost effective, high performance electronics are increasingly required in the automotive environment regardless of vehicle type. These products must withstand high temperature, vibration, wear, and abuse with reliabilities only superseded by products for defense applications. Continued *on-site* integration of microelectronic systems into automotive components, such as engine and drivetrain elements, require packaging and interconnect materials which meet industry's minimum 150^{o}C long term performance and reliability requirements.

This trend requires development and implementation of new high temperature resistant, low stress, dimensionally stable, electronic packaging and interconnect substrate polymer materials. At the same time, processes used for manipulation of these materials into electronic products must be compatible with existing manufacturing pathways. Delivery and implementation of new materials must match or undercut existing cost structures.

This subtopic solicits development of new, cost effective, high temperature packaging or interconnect polymer materials for next generation packages or interconnect substrates. Proposals to develop next generation reworkable underfills, thin film dielectrics, glob tops, or anisotropic conductive adhesives are sought.

8.12.6T/CC SUBTOPIC: Constitutive Equations for Lightweight Sheet Metal Forming

Increased use of lightweight metals in automobiles is essential to the achievement of PNGV goals for improved performance. The PNGV Manufacturing Team has identified reliable and predictable aluminum forming as one of the top 5 priorities in vehicle manufacturing needs. Industrial experience with lightweight metals is limited, and the use of computer methods (for example, finite element analysis, FEA) to predict forming behavior is being actively pursued by industry to accelerate the transition from traditional alloys. FEA employs constitutive equations to relate stress and strain. However, for the large strains and nonproportional loading paths occurring during and after sheet metal forming, presently employed constitutive equations are inadequate. Advanced equations that more accurately predict the mechanical behavior of metal undergoing large strain plasticity need to incorporate internal state variables. We seek the development of equations incorporating measurable, physically based state

variables (for example, parameters describing dislocation structures). It must be demonstrated that effective techniques exist or can be developed for non-destructive measurement of these variables and the internal state of deforming metals. Such an approach is likely to be useful in a variety of commercial applications ranging from the determination of residual stress to metal forming.

8.12.7T/CC SUBTOPIC: Process Monitoring and Control of Composites Processing

Composites manufacturing is a growing industry in the United States. However, quality control issues threaten to limit the growth of the industry in high production volume commercial sectors such as automotive. Inconsistency in part quality arises from a large number of sources, including catalyst, mixing, and resin variabilities. Another important source of inconsistency arises from flow variability caused by fiber preforms that do not perfectly fit mold contours. Process monitoring and control are expected to improve quality and drive down production costs.

Researchers at NIST have developed prototype optical fiber sensor systems for fluorescence and near IR monitoring of composites processing in response to industry needs for improved process control. NIST seeks proposals to explore the usage of optical fiber process monitoring systems for process control in liquid molding or pultrusion manufacturing environments. Proposals are also sought to refine, ruggedize, and miniaturize the optics and detector systems.

The current optical fiber fluorescence system can obtain complete spectra in under 0.1 s, in either distal or evanescent wave sensing mode, and has been laboratory tested with epoxy, polyurethane, and isophthalic polyester resins. The optical fiber near IR system uses the same inexpensive fiber as the fluorescence system, and is currently implemented with a standard FTIR. Evanescent wave near IR spectra are obtained in less than 4.5 s.

8.12.8T SUBTOPIC: Sensor for *In-Situ* Measurements of Thermal Spray Coatings

Thermal spray coatings are becoming more important as manufacturers simultaneously search for techniques for cutting costs and giving their parts and products greater reliability and wear resistance. To succeed, the manufacturers require measurement and diagnostic tools to better understand and control their processes. A sensor that gives more accurate temperature measurements, provides an indication of changes in texture (emissivity), and also gives an indication of coating quality, would be important in extending the applicability and reliability of thermal spray coatings. Researchers at NIST require a sensor or sensors to make localized measurements of temperature,

emissivity, texture, and coating quality of thermal spray coatings. This sensor is to operate during the thermal spray coating production process, and is to be usable for feedback and control of the thermal spray process. One promising approach is the use of an optical fiber thermometer in conjunction with multicolor pyrometry and simultaneous reflectance monitoring. NIST will entertain proposals that address the major elements of this measurement problem within this framework. Ideally, the sensor would be an innovative adaptation of tried and proven technology, so that it is immediately ready to secure the required data, and is likely to succeed as a feedback and control sensor.

8.12.9T SUBTOPIC: Intermediate-Load (1 N - 100 N) Instrumented Indentation Tester Development

The experimental technique of instrumented (or "depth-sensing") indentation is rapidly becoming the test method of choice for the measurement of mechanical properties, such as Young's modulus and hardness in small volumes of material. In this technique, an indenter tip is loaded onto the surface of a specimen and then unloaded, and the load on, and displacement of, the tip into the specimen are monitored continuously throughout the indentation cycle. Tips are typically diamond, and can be either of spherical or sharp pyramidal (Vickers, Berkovich) geometry. The resulting load-displacement curves are then analyzed to yield the specimen's Young's modulus, hardness, and other material properties.

To date, commercial instrumented indenters fall into two classes: those designed to operate at low to very low loads (from 1 N down into the microNewton range), and those based on universal test machines operating at several hundred to several thousand Newtons. The intermediate range of 1 N to 100 N is unavailable to purchasers of commercial machines, and the few researchers working in this regime must work with home-made devices. This gap in testing ability is significant, as it is the indentation load that determines the length scale over which mechanical properties are measured. At a load of 1 N, for example, indentation depths in glasses and ceramics are typically only a few micrometers, with contact areas between the tip and specimen on the order of 10 micrometers squared. While a probe on this length scale is appropriate for very thin films and fine-grained materials, there are many materials with coarser structure, such as plasma-sprayed coatings and composite materials, where much larger volumes must be sampled in order to correctly assess bulk material properties. The Ceramics Division has built a device for operation in this range, and although it is being used extensively, it has fundamental limitations in accuracy and

flexibility of use that severely restrict its utility. It is believed that a commercial machine of the type specified below would constitute a very viable product. We routinely receive calls asking how NIST data in this load range were obtained, and whether there is a commercial product available for this load range.

There is also currently no instrumented indenter in any load range that permits indentation of specimens at elevated temperatures. Since many material properties are strongly temperature-dependent, and since many materials are intended for high-temperature application, the capability to perform an instrumented indentation at elevated temperature (to 800 - 1000°C) is highly desirable. It is understood, however, that this design constraint severely complicates the machine design, and it is included here as a highly desirable, but not essential, component of the design.

The purpose of this proposal is to solicit the design and construction of a prototype indenter to operate in the 1 N to 100 N load range. The machine should be designed to meet the following specifications and performance criteria:

Load range:	1 N - 100 N.
Load resolution:	1 mN or 0.1%.
Displacement resolution:	1 nm.
Indentation location:	An optical system must be included, such that the location of an indentation can be preselected with approximately 1 micrometer precision on the specimen surface.
Operational control:	Operation of the system must be under computer control, such that all aspects of the indentation cycle (loading rate, maximum load, hold times, reloading, etc.) can be programmed in advance of the measurement.
Temperature range:	Specimen and indenter tip temperature from room temperature to 1000°C.

8.12.10T SUBTOPIC: Software for Optimization of Ceramic Lapping and Polishing

Lapping and polishing processes are used in industry as the final machining step to produce the desired geometrical form and surface finish. In the lapping and polishing operations the work-piece is pressed against a lapping plate, and a slurry containing abrasive particles in a carrier fluid (water or hydrocarbon based fluids with chemical additives) is used as the primary source for material removal. The removal of material occurs by a combination of micro-cutting and micro-fracture, and is often influenced by chemical reactions between the slurry, lapping/polishing plate, and work-piece material.

This is a highly complex process, and its optimization requires detailed knowledge of many interdependent factors. The major parameters include: the size distribution and shape of the abrasive particles, the mechanical and chemical properties of the abrasives, the chemistry and physical properties of the carrier fluid, the nature of the lapping/polishing plate, the applied pressure, rotational speed of the lapping plate, and the arrangement of the workpieces on the lapping plate. Each parameter is associated with several other variables that can influence the removal process. Optimization of the lapping/polishing process consists of finding the most appropriate set (or sets) of parameters to be used for each work-piece material, such that a desired geometrical form and/or surface roughness is achieved quickly. We invite proposals for the development of a software that can be used on personal computers for off-line optimization of lapping and polishing of ceramics and other advanced materials. The input variables could include the type of work-piece material and its mechanical and physical properties, work-piece geometry and desired dimensional form, type of abrasive used in the slurry, and desired surface roughness. The computer software would then give recommendations for the applied pressure, rotational speed, and time duration. The software must be based either on evaluated data or on a sound fundamental model, or combination of both. This software must be self-sufficient, robust, and user friendly, and it must have the potential for future modifications and expansions.

8.12.11T SUBTOPIC: Device and Technique for Measurement of Thermal Conductivity of Ceramic Powders

Models for thermal (plasma) spray and chemical processing of ceramic powders generally require thermal conductivity data for the powders. Typically data for bulk solids of the same nominal composition are used, although it is recognized that these values may differ significantly from powders. Additionally, the morphology, in terms of porosity distribution and agglomerate structure, may vary between powders of the same nominal composition. A technique and associated apparatus is desired, which can measure thermal conductivity of ceramic powders in the size range of 1 micrometer to 100 micrometers. Materials of interest include zirconia, tungsten carbide, alumina, and titania. Techniques and devices developed should be suitable for inclusion in concensus measurement standards such as ASTM.

8.12.12T SUBTOPIC: Wide Frequency Spectrometer for the Dynamic Heat Capacity

The heat capacity, which is the differential heat content of a sample as a function of temperature, can be treated as a dynamic linear susceptibility. As such it shares, with dielectric and mechanical susceptibilities, the feature of containing degrees of freedom that each relax with their own characteristic time constant τ. By analogy with these quantities, the heat capacity is frequency dependent and has real and imaginary parts. Thus, a spectrum of C_p in the frequency domain should, by means of Fourier inversion, provide valuable information for the study of thermal relaxation. However, the spectrum is not commonly available, as in the cases for dielectric or mechanical susceptibilities. There is no commercial instrument that adequately measures the frequency dependent heat capacity. Differential scanning calorimeters (DSC) have three failings: (1) they do not give absolute results; (2) they are not accurate; (3) even when they employ a sinusoidal temperature profile, they operate only over a narrow and low frequency range. A commercial wide frequency spectrometer for heat capacities is needed for the study of the thermal relaxation of polymeric material. The equipment should be low-cost, user-friendly, and operate over a wide temperature (175 K to 525 K) and a wide frequency (4 to 5 logarithmic decades, 0.1 to 10^4 Hz) range. Measurement in either time-domain or frequency-domain is acceptable.

8.12.13T SUBTOPIC: Object-Oriented Development Environment of Intelligent Process Control Strategies

The current state-of-the-art in systems for process control incorporates software tools that allow the creation of “virtual” operator controller front panels. The controller front panels contain actuators and displays that can be toggles and push-buttons, as well as dials and strip charts. The “smarts” of the controller is typically encoded in some proprietary language that may be graphical in form. This form of controller development has proven to be extremely useful, and has been widely adopted by the manufacturing community. The problem with this approach, however, is that the process control strategies still have to be developed, coded, and tested. This development process is still very expensive, and industry is eagerly waiting for solutions to this problem which will lead to a reduction in the development cycle time.

Proposals are sought for the development of an object-oriented approach to software development which reduces the development cycle time, as well as increases the reliability of the resulting code. The software tool, which is to be developed, should enable a process control operator to describe the manufacturing process in an object-

oriented fashion and to develop control strategies by distributing the intelligence of the controller among a number of concurrently executing managers, each of which will specify a control action to be taken in response to the state variables of the system.

The software tool is to take advantage of the current state-of-the-art in the areas of expert systems and fuzzy logic. The resulting control strategies developed with the object-oriented software tool, which is developed, are to be directly usable in the process controller development software tools discussed above, which are in wide use today.

8.13 NIST TOPIC: BUILDING AND FIRE RESEARCH

8.13.1T SUBTOPIC: Field Measurements of Transport Properties of High Performance Concrete

Transport processes in concrete play an important role in determining its utility, service life, and durability. Transport by diffusion and capillary suction are the primary means by which deleterious materials ingress concrete. Also, the permeability of concrete to water and gasses like radon are important in determining its utility for storage of hazardous wastes and as a barrier. We are interested in obtaining a device (or devices) which has the capability of determining the diffusivity of a molecular species, the water sorptivity, and the permeability of concrete to water or gasses in the field as a function of saturation. This device must have the capability to measure the transport properties of High Performance Concrete. For instance, chloride diffusion constants of as low as 10^{-13} to 10^{-14} m^2/s and water permeability as low as 10^{-22} to 10^{-23} m^2 may need to be determined. Other key features of this device include that it be portable, and is easy to use and make multiple measurements in the course of a working day.

8.13.2T SUBTOPIC: Intelligent Software Agent for High-Performance Construction Materials Knowledge Representation and Exchange

Efficient representation, access, and exchange of construction materials knowledge will advance the area of materials science research and use of knowledge by the construction industry. Timely, accurate, and high-quality knowledge is needed for improved decision-making. New methods must be developed and implemented that provide more efficient human to computer and computer to computer interfaces. The Building and Fire Research Laboratory is undertaking a large program that involves the

representation, integration, and dissemination of knowledge about construction materials. Knowledge within the system will be distributed and used world-wide.

BFRL is interested in the development and implementation of an intelligent software agent and architecture that will enhance the access and exchange of knowledge among industry, government, and academia. The volume and nature of construction materials knowledge will depend on innovative access and transfer methods that currently do not exist as a commercial product. Conventional information technologies (methods and procedures) do not address the current and future knowledge formats for the construction industry. An intelligent software agent must function in a distributed and heterogeneous computing environment. Leading-edge communications technologies must be used to transfer information between the human and computer entities. Databases, high-level reasoning, models, and audio/video knowledge must be communicated and presented seamlessly.

8.13.3T SUBTOPIC: Automated Knowledge Acquisition for Construction Materials Knowledge Representation and Exchange

Efficient representation, access, and exchange of construction materials knowledge will advance the area of materials science research and use of knowledge by the construction industry. Timely, accurate, and high-quality knowledge is needed for improved decision-making. New methods must be developed and implemented that provide more efficient human to computer and computer to computer interfaces. The Building and Fire Research Laboratory is undertaking a program that involves the representation, integration, and dissemination of knowledge about construction materials and systems. The major bottleneck in developing systems is the knowledge acquisition phase.

Proposals are invited for developing software tools and techniques that will support automated ontology and knowledge-base development. An ontology provides a rigorous specification to describe the relationships between the concepts of the terminology used to describe construction materials and systems, while the knowledge-base will use the specified concepts in the ontology for representing higher order knowledge. There is a need to understand the meanings and characterize differences in meanings for terms used in the construction industry, and to translate these meanings into representations that can work within a well defined knowledge sharing framework. Specific interests to this proposal include: (1) taking a machine readable dictionary and creating an ontology using automated tools, (2) taking machine readable documents and creating a knowledge-base using the constructed ontology and

automated tools, (3) taking machine readable documents and creating a machine readable dictionary using automated tools.

8.13.4T SUBTOPIC: Low-cost, Smart Vibration Sensors

If sufficiently low-cost vibration sensors were available, they could be used to shut off rotary and reciprocating machinery, such as air conditioning compressors and fans, before vibrations caused by worn bearings or other malfunctions damaged the machinery or other equipment connected to it. Low overall cost is essential for such a sensor. Low fabrication cost is required, but is not itself sufficient. All costs, which include the cost of setting up commercially viable fabrication facilities, as well as the costs of packaging, interfacing, and calibrating the sensor must be very low. MEMS technology appears to have the potential to meet these needs, but current MEMS vibration sensors are still too expensive in many of the categories mentioned above. NIST welcomes proposals for a proof of concept study that addresses most if not all of the cost issues mentioned above, as well as the technical issues of producing a vibration sensor that is robust and reliable enough for use to shut off excessively vibrating machinery in commercial settings.

8.13.5T SUBTOPIC: Visualization of Building Information

In order for the design and engineering community to utilize fire hazard analysis and performance based fire codes in developing reasonable alternatives to the prescriptive codes used today, a method needs to be developed to connect rooms and buildings in a realistic way. Such a paradigm needs to be implemented in a way that allows the user to "drag" information along with the construction connections. NIST has developed a series of models which predict the effect that a fire will have on a specific building and its occupants. The difficulty is describing complex structures sufficiently well that a designer can feel confident that the building is representative of the actual structure to be built, and an approving official can feel confident that the building which is built will indeed meet the appropriate level of safety. This means that a visual method must be developed to provide the physical connections needed for a fire model and to place people within a building. Nominally, it should be implemented in a computer-aided design package.

A computer program is needed which runs on a micro computer (IBM PC class), which will provide a visual interface to NIST fire models. It may be based on a CAD package, so long as that package is generally used in the field of building design. The implementing code should conform to the standards as promulgated in NIST reference guides, and should allow textual information and databases to be made available to the various models as the building is "constructed." Such a package would follow the standard techniques used by A&E firms in laying out buildings for visualization of

construction, but would provide the additional capability of interior connections and construction materials, which would allow an assessment of fire safety to be made. This should follow and highlight the requirements as set forth in the consolidated model building and fire codes.

References:

NIST Handbook 146, Volumes I and II. 1992. The Fire Hazard Assessment Method. National Institute of Standards and Technology.

NIST Technical Note 1299. 1993. CFAST, The Consolidated Model of Fire Growth and Smoke Transport.

8.13.6T SUBTOPIC: Sweating Thermal Conductive Performance Apparatus for Evaluation of Fire Fighter Protective Clothing

The fire service is experiencing thousands of burn injuries each year. Many of these injuries are associated with the buildup of moisture inside of the fire fighter's protective garments. Sweat and water from fire fighting activities will saturate the garments, which results in a change in their thermal performance. When the protective garments are heated by the fire fighting thermal environment, heat transfer rates increase as a result of moisture in the protective clothing. In addition, this moisture can be quickly heated to temperatures which can cause scald burn injuries.

An apparatus is needed for accurately measuring the changes in thermal performance of fire fighter protective clothing under various levels of wetting. The apparatus must have the capability of adding moisture to garment materials in a controlled fashion, with distribution and rates representative of a sweating human. The apparatus must be able to measure the thermal performance of protective garment systems, while maintaining their normal loft, and under various quantified levels of compression. The apparatus must be able to accurately measure the thermal performance of protective garments over a range of thermal environments experienced by fire fighters. The accuracy of these thermal measurements should be $\leq$ 5 %, within a single laboratory. NIST welcomes proposals which will result in the development of a robust and accurate measurement apparatus that will aid in understanding the thermal performance of fire fighter protective clothing.

8.13.7T SUBTOPIC: Water Mass Concentration Measurements in Fire and Sprinkler Driven Gas Flows

The Building and Fire Research Laboratory (BFRL) is developing models to predict the interaction of sprinklers and fires in buildings as a means to support computational evaluations of fire suppression system performance. An important variable in the model predictions and in determining the performance of fire suppression systems is the spatial and temporal distribution of water in the form of droplets from the sprinkler. Innovative proposals are solicited by BFRL for a droplet sensor to measure the local liquid water concentration in the gas flow produced by the interaction of the fire and water spray from the sprinkler. Expected temperatures in the fire driven flows are up to 500^{o}K, with droplet diameters less than 1 mm. Important considerations include spatial resolution, minimum sampling rates of 1 Hz, ease of use, robustness in fire test environments, ability for automated data acquisition, and reasonable cost.

8.13.8T SUBTOPIC: Advanced Incident Command System

Currently, many fire departments follow a prescribed protocol for handling incident command for a wide variety of emergencies. This system provides command structure and allows for the direction of all resources on the scene from a central location. Unfortunately, communication is typically limited to radio transmission. Confusion can easily occur due to miscommunication or lack of communication between the engine companies and the incident commander. Many times the resources are not positioned where they are needed the most. Or, in the case of conflagrations,it may not be clear where the resources are needed the most.

NIST has been developing a high resolution wildland/urban, wind driven fire spread computer model. When completed, the model will incorporate a wide variety of spread mechanisms and be able to run on a PC laptop. The software requirements for this model and computer capabilities should converge within the next three years.

Innovative proposals are solicited by BFRL for a PC based advance fire incident command system to provide equipment and resource tracking via GPS, and system of computer based maps onto which the results of NIST's predictive models could be overlaid. Important considerations include compatibility with the NIST model, the framework and expected input and outputs of which will be supplied to respondents, ease of use, and run time on portable windows based PCS.

8.13.9T SUBTOPIC: Integrated Fire Fighter Safety System

Fire fighters are experiencing thousands of burn injuries each year. NIST has a project to measure the "stored energy" in fire fighter protective clothing. NIST has found that by the time the fire fighter feels the heat through the gear, there is no time for corrective action, and a burn injury occurs. The fire fighter needs some type of warning system to provide time for corrective action prior to suffering a burn injury. The next step in the NIST fire fighter safety project is to develop a predictive heat transfer model based on the thermal inputs to the outer shell of the protective garment. If this predictive method could be tied into a lightweight, inexpensive, sensing, decision and warning device, many fire fighters could be spared the pain and suffering due to burns each year.

A system is needed for sensing, analyzing, and warning prior to the onset of thermal injury. This system would be robust in order to withstand the daily rigor of a fire fighting environment. Ideally, the system could be retrofit to existing gear.

8.13.10T SUBTOPIC: Rapid Scanning Near IR/IR Spectrometer

The transient, non-intrusive, simultaneous measurements of CO_2 and H_2O concentrations, soot volume fraction, and temperatures of soot and CO_2 in flame are critically needed to understand the flame structure. In order to conduct such measurements, a rapid scanning spectrometer or an array detector is required in the wavelength range from 1 to 5 microns. The concentrations of CO_2 and H_2O and temperatures will be determined by the measured emission spectra from the flame. The required spectral resolution is 15 nm, and the scanning rate (from 1 to 5 micron) should be better than 500 Hz. The field of view should be collimated to within a 2 mm diameter. The accuracy of the concentration measurement should be within ± 0.005 mole fraction, with a minimum detectable concentration of 0.01 mole fraction, ± 5% for the temperatures, with a minimum detectable temperature of 800 $^{\circ}$K, and ± 20% for the soot volume fraction, with a minimum detectable fraction of 10^{-6}g/cm^3. The device should be small enough to be easily moved from one laboratory to another by a single person without using a cart.

8.13.11T SUBTOPIC: Advanced Detection and Monitoring of Fires

A properly designed fire detection system must be able to identify, in a matter of seconds, a fire event which may occur only once in one hundred years, and the identification must lead to an action which is appropriate to the space being protected. Spaces of interest to the Building and Fire Research Laboratory include residential and

commercial structures, industrial facilities, transportation systems, and the urban/wildland interface. False alarms, maintenance problems, and incomplete or inaccurate information, which leads to an improper suppression response, are problems that plague many fire detection and/or suppression systems which are economically competitive. As the scientific basis for the identification of the characteristics of a pending fire become better established, research is required to determine how to apply advances in sensing temperature, heat flux, chemical species, particulate matter, and different portions of the electromagnetic and acoustic spectrum to the detection of a hazardous fire. New methods of signal processing and decision-making, based upon the most effective use of available knowledge, and the development of systems which adapt to changes to the environment being protected, are of particular interest. Proposals for incremental advances to existing fire detection technologies are not solicited. Refer to related descriptions in annual summaries of BFRL research.

8.13.12T SUBTOPIC: Advanced Fire Suppression and Novel Suppression Concepts

Fire protection of facilities requires suppressants that will not harm the environment nor cause excessive collateral damage to a structure or its contents. The need for alternatives which have low toxicity constrains one's choice of chemicals even more, suggesting that improved means for storage and delivery of less effective (but inherently safe) materials need to be addressed. Proposals are solicited which will improve any aspect of automatic fire suppression systems, such as more efficient storage of the agent, timely and precise delivery to the space being protected, enhanced interaction of the agent with the fire, and minimal negative interaction with the surroundings. Means to evaluate novel concepts at a reduced-scale which reliably predict full-scale operation should be addressed in the proposal. Inert gas systems and fine water sprays have little detrimental environmental impact. Methods to enhance their effectiveness as fire fighting agents and overcome their deficiencies (large quantity requirements and possible asphyxiation for inert gases, and significant collateral damage for water sprays) are legitimate topics. Other currently proposed halocarbon substitutes for halons are saddled with known or potential negative impacts on stratospheric ozone depletion or global warming, and it is unlikely that new compounds from this family will have both short atmospheric lifetimes and zero ODP. Approaches to more precisely predict the chemistry of alternative compounds in the atmosphere and to hasten their conversion to the most environmentally-friendly end-state are also sought. Refer to related descriptions in annual summaries of BFRL research.

8.13.13T SUBTOPIC: High Heat Flux Gauges and Calibrators

More precise measurement of heat flux in harsh, high temperature environments is required to understand and model the spread of unwanted fires. Proposals are solicited for novel transducers which can measure (and distinguish between) radiative and convective heat fluxes at levels up to 100 kW/m^2. Operational requirements include time response greater than 10 Hz, output linearity (within ± 5%) from 0.5 to 50 kW/m^2, flat spectral response in the visible and near infrared, size less than 4 cm^2, operating temperatures up to 300 °C, and resistance to condensation or particulate build-up. Proposals for methods or fixtures to calibrate heat flux gauges (traditional as well as new designs) in convective environments up to 50 kW/m^2 are also invited. Refer to the proceedings of a workshop on high heat flux calibration held at NIST in January 1995.

8.13.14T SUBTOPIC: Toxic Environmental Monitor for Fire Fighter and Research Use

The fire service experiences about 20 fire deaths each year. Some of these deaths are caused by the firefighter assuming incorrectly that the local atmosphere is sufficiently viable that escape will be possible even in the event of depletion of the self-contained breathing apparatus (SCBA) air supply which is normally employed. The primary toxic gases generated by fires are carbon monoxide (CO) and carbon dioxide (CO_2). Depletion of oxygen (O_2) leads to unconsciousness as well. A monitor is needed for measuring CO, CO_2, and O_2 levels simultaneously and providing a readable output to the firefighter's SCBA face shield. The monitor should also include a microcomputer that uses an algorithm to provide a conservative estimate of the time a typical person would be able to remain conscious in such an environment. The research use of the monitor would be for fire testing in which spatial resolution of gas concentrations is desired. For low temperature environments, the monitor could be placed at the site of interest, while for high temperature environments, the monitor would be exposed to extracted gases at a distance. The first generation monitor must have compact and lightweight sensors that together weigh less than 0.5 kg and have potential for further miniaturization. Control of the prototype system can be by microcomputer. The size of the system without the microcomputer must fit within a 100 cm^3 volume. It is expected that the microcomputer would eventually be replaced by a dedicated chip. The apparatus must be capable of withstanding a 100°C environment for 20 minutes. The accuracy of the CO and CO_2 sensors must be within 10% of their nominal readings, while the O_2 sensor must be within 5%. The system must be able to refresh visual and analog outputs at least once every 5 seconds. The ultimate cost of the components

must be below $1000. NIST welcomes proposals which will result in the development of a safety and measurement apparatus for the fire service and research communities.

8.13.15T SUBTOPIC: Temperature Measurements During Water Sprinkler Extinguishment of Fires

The development of models for describing the extinguishment of fires by water sprinklers is a current research priority of the Building and Fire Research Laboratory (BFRL). An important parameter to be used for validation of such models is the gas temperature field in the region influenced by both the sprinkler and the fire. Such measurements are particularly difficult due to the presence of both heated fire gases and water droplets. Innovative proposals are solicited by BFRL for a temperature sensor which is capable of measuring local gas-phase temperatures (room temperature to 500^{o} K) with a minimum sampling rate of 100 Hz during sprinkler-extinguishment of fires. Important considerations include high spatial resolution, ease of use in fire test, robustness, ability for automated data acquisition, and reasonable cost.

8.13.16T SUBTOPIC: Advanced Temperature Probe for Fire Testing

As the computational methods used to model fire scenarios become more sophisticated, there is a pressing need to improve the temporal and spatial resolution and reduce the uncertainty of temperature measurements used for validation. Presently used thermocouple methods are plagued by uncertainties. Temperature measurements are difficult in fires because of thermal radiation incident on the thermocouple from the fire (if the local gas is cooler than the surroundings), radiation losses from the thermocouple to the surroundings (if the local gas is hotter than the surroundings), soot accumulation on the thermocouple, and non-uniform heat transfer from the gas to the thermocouple due to recirculation and turbulence. The temporal response of thermocouples is limited by the thermal inertia of the bead, and time constants are often difficult to estimate. In addition, the metal structures on which thermocouples are mounted act as heat sinks and disturb the local flow. Proposals are solicited for innovative gas temperature measurement techniques for use in and around fires which are more accurate and precise and possess better spatial and temporal resolution than thermocouples. New methods should be able to measure local gas temperatures between 300 and 1500 K in an environment characterized by large temperature gradients, spatially and temporally nonuniform radiation fields, soot, and turbulence. New sensors should be rugged, long-lasting, and inexpensive. Rapid temporal response on the order of 1 ms and spatial resolution of less than 1 mm are desired to resolve local turbulence scales in fires. A technique capable of performing planar temperature measurements while satisfying the above listed constraints is desirable for validation of computer simulations. The temperature technique should minimize disturbance to the fire flow field, and should possess excellent and easily

calculable precision and accuracy. Only novel and innovative temperature probes will be considered.

8.13.17T SUBTOPIC: Rapid Time Response Heat Release Rate Sensor for Fire Testing

The release of fire-fighting agents and subsequent extinguishment of accidental fires takes place in a time period as short as 30 milliseconds. Few details are known about suppression under these conditions, because few instruments are capable of responding rapidly enough to resolve the behavior of the fire. One measurement which is necessary for studying suppression is the temporally resolved heat release rate of the fuel. The heat release rate is not necessarily equal to the mass loss rate of fuel; all of the fuel which evaporates does not necessarily burn. The heat release rate is the energy per unit time released by the fuel as it reacts with oxygen. Proposals are solicited for a heat release rate meter for liquid pool fires with a 1 ms temporal response and the capability to resolve fires of 10 kW to 5 MW. The meter should be designed to withstand the environment typical of pool fires of this size. The meter should also be able to measure temporally resolved heat release rate while the fire and fuel pan are interacting with an overhead extinguishing agent release. The heat release rate sensor should be rugged, long-lasting, minimize disturbance to the fire flow field, and possess excellent and easily calculable precision and accuracy. Only novel and innovative heat release rate sensors will be considered.

8.13.18T SUBTOPIC: Molecular Dynamics Modeling of Polymer Reactivity

Molecular dynamics (MD) has been demonstrated to be a useful tool for the investigation of time dependent properties in synthetic polymers. Recent work conducted in the Building and Fire Research Laboratory has led to extensions of MD to account for the major reaction channels involved in the thermal degradation of polymers. This was accomplished by introducing specific reaction pathways, which are known to be active in the thermal degradation of polymers, and switching functions, which turn-on new bonding interactions, when the old bonds approach dissociation, into the force field. There is a clear need to augment this model to account for a greater range of chemical properties and reactivity, including the capability to model polymer-monomer and monomer-monomer reactions. NIST welcomes proposals for the further development of our reactive MD code, which could be used within the polymer industry to develop new strategies for polymer synthesis and processing.

References:

Nyden, M.R., G.P. Forney, and J.E. Brown. 1992. Molecular Modeling of Polymer Flammability: Application to the Design of Flame-Resistant Polyethylene. Macromolecules, **25**, 1658.

Nyden, M.R., T.R. Coley, and S. Mumby. 1997. Applications of Molecular Dynamics to the Study of Thermal Degradation in Aromatic Polymers. I. Polystyrene, *Polym. Eng. Sci.*, in press.

8.14 NIST TOPIC: INFORMATION TECHNOLOGY

8.14.1T SUBTOPIC: Extending RBAC to Include Work flow Properties

Work flow technology is the means by which business processes are automated and controlled. It has long been observed that RBAC concepts seem to complement and to some extent support work flow concepts. RBAC is a technology that allows for the specification and enforcement of a variety of protection policies which can be tailored on an enterprise-by-enterprise basis. The policies enforced in a particular system are the net result of the precise configuration of the various components of RBAC. It is felt that RBAC components can support or can be extended to support the specification of a business process in the context of a work flow. A Business Process is a set of one or more linked procedures or activities which collectively realize a business objective or policy goal, normally within the context of an organizational structure defining functional roles and role relationships. A process definition generally consists of many process activities which are logically related in terms of their contribution to the overall realization of the business process. These notions seem to map well to the RBAC framework that provides administrators with the capability to regulate who can perform what actions, when, from where, in what order, and in some cases under what relational circumstances.

NIST seeks research and experimental implementation to:

(1) Explore existing work flow approaches and standards to determine the degree in which RBAC models currently complement and support work flow concepts.

(2) Develop an extended RBAC model to include work flow concepts, whereby the extended model can be used to directly provide a means by which a work flow management system can ensure that the activities which make up a work flow are carried out in the correct sequence as prescribed by a predefined or ad hoc business process.

(3) Develop a prototype implementation exhibiting the properties of the extended model and a demonstration that shows the applicability of the model to real world business applications.

8.14.2T SUBTOPIC: Secure Programming Development Tools

New operational security vulnerabilities are continuously being discovered, exploited, reported, and catalogued. Vendors normally release software patches for these vulnerabilities once they are reported, while others release security scanning tools to detect them. Several forums and organizations are dedicated to tracking, analyzing, and reporting new vulnerabilities. The existence of these products and activities underscores the need for design strategies and supporting automated design and development tools to prevent security vulnerabilities from being introduced into products during both the design and development phase of the product.

The goal of this initiative is to develop tools that will enforce secure software design and development methodologies. The Secure Programming Development Tools envisioned for this effort should help developers design security into their products from the concept inception, and not as an afterthought. These tools should detect weaknesses in software engineering practices that lead to security problems, and help developers identify suspect code before the products are released for commercial use. Additionally, such tools, which also detect in legacy or existing code vulnerabilities, flaws, and/or poor software engineering practices that lead to tangible security weaknesses, are also highly desirable.

8.14.3T SUBTOPIC: Natural Language Interface to 3-D Character Animations

The use of animated human or human-like characters to supplement voice and text communication has long been recognized as a means of improving the motivational response to and/or clarity of multimedia presentations. When media presentations are prepared off-line, it is possible to develop predetermined 2-D character animations that convey specific meanings. This method does not work, however, when the character must interact to user responses with a shorter duration between events than the length of the animations, or when the character must be viewed interactively from multiple viewpoints. In these cases, a real-time 3-D representation of the character is required. Such 3-D characters have been used in multi-user web-based environments enabled by the emerging Virtual Reality Modeling Language (VRML). However, the expressions and/or gestures of these "avatars" have lacked visual realism and have been directly controlled as a response to a user selection from a small set of pre-defined actions. In

addition, control of human simulations which follows the Humanoid Animation Working Group (HANIM) of the VRML consortium is desired to improve portability and interoperability of systems. What is needed is a character that responds with enhanced realism to user or simulation initiated events.

8.14.4T SUBTOPIC: Improved Noise Robustness and Speech Detection for Large Vocabulary Continuous Speech Recognition (CSR) Technology

Current state-of-the-art CSR systems experience degradation of performance in the presence of background noise, especially when using other than head-mounted microphones. Current systems also cannot reliably discriminate between background noise and speech in background noise. Improved technology is needed to improve noise robustness for both continuous (stationary) and impulsive noise, and to discriminate between speech and noise. Ideally, the improved technology would permit reliable use of CSR technology with low-cost, remotely positioned microphones, and eliminate reliance on the use of push-to-talk microphones. This technology should also be valuable in automatic transcription and indexing of radio and TV broadcast materials, especially those portions of the broadcasts originating in other than broadcast studios.

8.14.5T SUBTOPIC: Ipv6/Ipsec

IP security is an emerging Internet technology that is currently under development, starting to be deployed, and will have a major impact on the Internet of the future. IP security involves the addition of IP-level headers that can provide authentication, integrity, and confidentiality to Internet traffic, along with protocols to handle the negotiation and management of the keys that will be used to protect this traffic. (For further information see: http://www.ietf.org/html.charters/ipsec-charter.html.) The IETF (Internet Engineering Task Force) documents that define these protocols are concerned with the formats of the packets that travel across the Internet, those packets that negotiate the key establishment, and those that carry the authenticated and/or encrypted messages.

These documents do not deal with a critical related issue: how can a system administrator or user enable these capabilities, specifying and controlling the system's security policy? Two interfaces are needed to accomplish this: an application-level interface that can be used by system administrators and users, and an API that can be called by application programs. It would be useful to design such an interface and then implement and test it. The interface should be compatible with and run under both the current Internet technology (IPv4) and the future Internet technology (IPv6). (For

further information, see: http://www.ietf.org/html.charters/ipngwg-charter.html, or http://playground.sun.com/pub/ipng/html). It should also run on a wide variety of computers and operating systems.

8.14.6T SUBTOPIC: Automated Network Security Administration and Configuration Tools

As the rate at which new products are being introduced into the market continues to increase, so does the complexity of securely administering distributed networks of personal computers, workstations, firewalls, web servers, and routers. Moreover, as new hardware, new software applications, vendor patches and upgrades, and network connections are continuously added to an organization's network, it is difficult to determine if the system is in a safe-state, and if the organization's security policy is being properly implemented and enforced. System administrators would benefit greatly from an Automated Network Security Administration and Configuration Tool that helps them securely configure and maintain distributed systems. These tools could, for example, include network resource discovery routines, track the installation of vendor patches, identify security vulnerabilities, and analyze the organization's security policy to ensure that it is being properly implemented. The goal of this effort is to develop a method for automatically configuring and maintaining the secure state of an organization's network system and a set of support tools that embody the method.

PARTNERSHIP FOR A NEW GENERATION OF VEHICLES (PNGV)

The PNGV is a historic new partnership between the Federal Government and the U.S. Council for Automotive Research (USCAR), which represents Chrysler, Ford, and General Motors. The partnership is aimed at strengthening competitiveness by developing a broad range of technologies for a new generation automobile. This vehicle will be energy efficient, have low emissions and be developed in an accelerated time frame. The three goals of the PNGV program are:

- Significantly upgrade manufacturing technology, by such actions as adoption of agile, and flexible manufacturing, and reduction of cost and lead times. Do this while reducing environmental impact and improving quality.

- Improve fuel efficiency and emissions of standard vehicles, while pursuing safety advances. Research will focus on technologies that reduce the demand for energy by the engine and drive train.

- Within a decade, achieve fuel efficiency up to three times that of the average 1994 Chrysler Concord, Ford Taurus, and Chevrolet Lumina. Achieve this with equivalent performance and purchase price, after adjustment for economics.

The following subtopics specifically apply to the PNGV Program:

8.9.1T/A/CC	Computational Tools to Support Design Artifact Knowledge Repositories
8.9.3T/CC	Green Engineering Concepts for Next Generation Vehicles
8.11.6T/CC	High-Resolution Two-dimensional Active Electronic Neutron Detectors
8.12.5T/A/CC	Next Generation Electronic Materials for High Temperature Automotive Electronic Packaging
8.12.6T/CC	Constitutive Equations for Lightweight Sheet Metal Forming
8.12.7T/CC	Process Monitoring and Control of Composites Processing

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9.0 SUBMISSION FORMS

Proposal to the Department of Commerce
COVER PAGE

PROGRAM	This firm and/or Principal Investigator ____ has ____ has not submitted proposals for essentially equivalent work under other federal program solicitations, or ____ has ____ has not received other federal awards for essentially equivalent work.
SBIR – SMALL BUSINESS INNOVATION RESEARCH	

SOLICITATION NO.:	CLOSING DATE:
DOC 98-1	January 14, 1998

NAME OF SUBMITTING FIRM

ADDRESS OF FIRM (INCLUDE ZIP CODE)

TITLE OF PROPOSED PROJECT

REQUESTED AMOUNT	PROPOSED DURATION
$	**6 months**

SOLICITATION SUBTOPIC NO.	SOLICITATION SUBTOPIC TITLE

THE ABOVE ORGANIZATION CERTIFIES THAT:	YES	NO
1. It is a small business firm as defined on page 3.		
2. The primary employment of the principal investigator will be with this firm at the time of award and during the conduct of the research.		
3. A minimum of two-thirds of research will be performed by this firm in Phase 1.		
4. It qualifies as a minority and disadvantaged small business as defined on page 3.*		
5. It qualifies as a woman-owned small business as defined on page 3.*		
6. It will permit the government to disclose the title and technical abstract page, plus the name, address and telephone number of the corporate official if the proposal does not result in an award to parties that may be interested in contacting you for further information or possible investment.		

PRINCIPAL INVESTIGATOR/ PROJECT DIRECTOR	CORPORATE OFFICIAL (BUSINESS)	OTHER INFORMATION
NAME	NAME	YEAR FIRM FOUNDED
SIGNATURE	SIGNATURE	NUMBER OF EMPLOYEES Avg. Previous 12 mos. _____ Currently _____
TITLE	TITLE	HAS THIS PROPOSAL BEEN SUBMITTED TO ANOTHER AGENCY? Yes _____ No _____
DATE TELEPHONE NO. + AREA CODE	DATE TELEPHONE NO. + AREA CODE	IF YES, WHAT AGENCY?

* For statistical purposes only

PROPRIETARY NOTICE

For any purpose other than to evaluate the proposal, this data shall not be disclosed outside the Government and shall not be duplicated, used or disclosed in whole or in part, provided that if a funding agreement is awarded to this proposer as a result of or in connection with this submission of this data, the Government shall have the right to duplicate, use, or disclose the data to the extent provided in the funding agreement. This restriction does not limit the Goverment's right to use information contained in the data source without restriction. The data in this proposal subject to this restriction is contained on separate proprietary page(s).

9.0 SUBMISSION FORMS

Department of Commerce
Small Business Innovation Research Program
PROJECT SUMMARY

NAME OF FIRM	AMOUNT REQUESTED
ADDRESS	PHONE # FAX #
PRINCIPAL INVESTIGATOR (NAME AND TITLE)	
TITLE OF PROJECT	
SOLICITATION SUBTOPIC NO.	SOLICITATION SUBTOPIC TITLE
TECHNICAL ABSTRACT (LIMIT TO 200 WORDS)	
POTENTIAL COMMERCIAL APPLICATIONS OF THE RESEARCH	

BUDGET INSTRUCTIONS

The offeror is to submit a cost estimate with detailed information for each element, consistent with the offeror's cost accounting system. This does not eliminate the need to fully document and justify the amounts requested in each category. Such documentation should be contained, as appropriate, on a budget explanation page immediately preceding the budget in the proposal.

1. Principal Investigator (PI).

The PI must be with the small business concern at the time of contract award and during the period of performance of the research effort. Additionally, more than half of the PI's time must be spent with the small business firm during the contract performance.

2. Direct Labor.

All personnel (including PI) must be listed individually, with the projected number of hours and hourly wage.

3. Overhead Rate.

Specify current rate and base. Use current rate already negotiated with a Federal agency, if available. If no rate has been negotiated, a reasonable overhead rate may be requested, which will be subject to approval by DOC.

4. Other Direct Costs.

List all other direct costs which are not described above (i.e. consultants, subcontractor, travel, and equipment purchases). Each of the above needs a detailed explanation and elaboration of its relation to the project.

5. Materials.

The materials and supplies required for the project must be identified. There is also a need to specify type, quantity, unit cost, and total estimated cost of these materials and supplies.

6. General & Administration (G&A).

Specify current rate and base. Use current rate already negotiated with a Federal agency, if available. If no rate has been negotiated, a reasonable G&A rate may be requested, which will be subject to approval by DOC.

7. Profit.

The small business may request a reasonable profit (about 7 percent ofcosts is the average proposed).

SBIR PROPOSAL SUMMARY BUDGET

FIRM:	PROPOSAL NUMBER: (Leave Blank)

PRINCIPAL INVESTIGATOR:

	TOTAL PRICE
DIRECT LABOR:	$
OVERHEAD RATE:	$
SUBTOTAL:	$
OTHER DIRECT COSTS:	$
MATERIALS:	$
SUBTOTAL:	$
GENERAL AND ADMINISTRATIVE (G&A):	$
PROFIT:	$
TOTAL PRICE PROPOSED:	$

TYPED NAME AND TITLE: SIGNATURE:

THIS PROPOSAL IS SUBMITTED IN RESPONSE TO DOC SBIR PROGRAM SOLICITATION 98-1
AND REFLECTS OUR BEST ESTIMATES AS OF THIS DATE.

DATE SUBMITTED: _____

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CHECKLIST OF REQUIREMENTS

Please review this checklist carefully to assure that your proposal meets the DOC SBIR requirements. Failure to meet these requirements may result in your proposal being returned without consideration. **Seven copies of the proposal must be received at DOC by Noon EST January 14, 1998.**

_____ 1. The proposal is **25 PAGES OR LESS** in length.

_____ 2. The proposal is limited to only **ONE** of the subtopics in Section 8.

_____ 3. The proposal budget is for **$75,000 or LESS** (or $50,000 or less for those topics designated as "SG"). No more than one-third of the budget goes to consultants and/or subcontractors.

_____ 4. The abstract contains **no proprietary information** and does **not exceed** space provided on the Project Summary.

_____ 5. The proposal contains only pages of 21.6cm X 27.9cm size (8 ½" X 11").

_____ 6. The proposal contains **an easy-to-read font (fixed pitch of 12 or fewer characters per inch or proportional font of point size 10 or larger) with no more than 6 lines per inch,** except as a legend on reduced drawings, but not tables.

_____ 7. The **COVER PAGE** has been completed and is **PAGE 1** of the proposal.

_____ 8. The **PROJECT SUMMARY** has been completed and is **PAGE 2** of the proposal.

_____ 9. The **TECHNICAL CONTENT** of the proposal begins on **PAGE 3** and includes the items identified in **SECTION 3.3.3** of the solicitation.

_____ 10. The **SBIR PROPOSAL SUMMARY BUDGET** has been completed and is the **LAST PAGE** of the proposal.

_____ 11. The P.I. is employed by the company.

NOTE: Proposers are cautioned to be careful of unforeseen delays that can cause late arrival of proposals at DOC, with the result that they may be returned without evaluation.

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